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INCANDESCENT LAMP PATENTS.

THE result of the appeal in the action brought by the Edison and Swan Company against Messrs. Woodhouse and Rawson can scarcely be held entirely satisfactory by either of the parties. The company would doubtless be quite content to rest upon the decisions it has already gained without running the risk of further expenditure in law costs, and without once more incurring the possibility of defeat. But the fact of Lord Justice Cotton's difference from his learned brethren will be strong encouragement to the defendants to go still further with their appeal and obtain the ruling of the House of Lords upon the validity of Edison's patent for incandescent lamps and the construction to be put upon the claims of that patent. The judgment delivered in the Appeal Court last Monday is fully set out in another part of this Journal, and will doubtless be eagerly perused by our readers. And it is worthy of the most careful study. It is quite refreshing to find that there is at least one judge of eminence who has sufficient boldness and independence to break away from what seemed fast becoming a ruling principle in litigation of this kind—that is to say, the upholding at all costs of well-established patents. The name of Edison has been one to conjure with in the British Law Courts, and although we do not wish to suggest that all alleged anticipations have not received honest consideration, nor that the question of infringement has not been minutely investigated, yet we think there has been too great a tendency to credit Edison with the discovery of first principles, and to regard his specifications as such statements of those principles and such claims for their utilisation as entitle him to hold the field against all other inventors, no matter how different the modes they employ. The fact seems to have been overlooked that every one of the principles upon which Edison's numerous and valuable inventions have been based were perfectly well known long anterior to the period of his labours, and that all he has done has been to employ them in a manner to some extent novel. Can it be possible that any one man may acquire the sole privilege of using the forces of nature for a particular purpose? It seems a preposterous claim, for instance, that Edison or Bell, or any other patentee, should be entitled to prevent others from putting to use their knowledge, such knowledge being general, that sound is capable of being transmitted over a length of wire with the assistance of an electric current, or that by the employment of an alternating or any other kind of current articulate speech may be reproduced at a distance. The particular mechanism by which he utilises the effects of such a current is all, in our view, to which a patentee has an exclusive right. In the present instance, it is true, it was conceded by the plaintiffs that the possibility of rendering incandescent a substance offering great resistance to an electric current, when that substance is placed as a connection between two freely conducting wires, was known at the date of Edison's patent, his claim being for a specific kind of resisting substance and its use in a particular combination. But the counsel engaged for the plaintiffs have shown in this case, and in other similar suits, a faculty truly Procrustean for varying the construction to be placed upon the language of specifications, and it is no small satisfaction to find their views for once discredited. We hail the tone of the remarks of the Appeal Judges—both those of the two Lords Justices whose judgment takes effect, and those of their dissentient brother and president, which remain only as an opinion—as indicating an important departure from recently-established precedent.

ANONYMOUS CORRESPONDENCE.

SOME ethical questions in journalism seem never to receive a definite settlement. Over and over again has the propriety of publishing unsigned articles containing expressions of opinion, or articles or letters of any kind with feigned signatures, been discussed, but we are cognizant of no *pronunciamento* upon the point which has proved universally acceptable. It is, perhaps, one of those questions which will not admit of an absolute rule, and where practice in individual cases must be left to the good sense and discernment of the persons concerned. Certainly it is possible to imagine circumstances which might render it inconvenient or otherwise undesirable that the authorship of valuable articles or interesting correspondence should become generally known. As regards that class of journalistic literature with which we are associated, when purely scientific matters are dealt with it is reasonable enough to concede a writer the option of hiding his identity under a *nom de plume*; he may seek assistance in solving a difficult problem, may desire to discuss technical points of an obscure character, or may wish to air his knowledge (or want of knowledge) in special branches of science; he may be modest, or he may shrink from exposing his lack of information; may, in short, have good reasons for withholding his name, and we have no reproof to bestow upon him. But there is another class of correspondents to whom no sort of grace should be granted in this respect, though they are as a rule amongst the most anxious to remain unknown. We allude to those (and they are a numerous band) who, departing from the lines of legitimate controversy, introduce the personal equation and, when they do not openly vilify their opponents, by sly insinuation suggest that those opponents have said "the thing which is not," are no better than they should be, or *would* be guilty of grave misdemeanour if opportunity served. Correspondence of this description should, of course, be strictly suppressed; but there are milder forms of the same evil which may escape the editorial scalpel by virtue of association with more valuable matter, and it is in such cases more particularly that we would insist upon the publication of the correct name of the writer. In communications with which we ourselves have been favoured there has not always been freedom from features of an objectionable character, and, without expressing an opinion as to the merits of the case between Sir Charles Bright and our correspondent of last week of whose anonymity the former complains in another part of the present issue, we take this opportunity of warning those of our correspondents who are prone to indulgence in personal criticism that, unless their names are printed, we shall exercise our right of suppression with possibly greater frequency in future, and shall certainly reject their contributions when the latter contain any suggestion of the faults of which we have spoken.

PRACTICAL NOTES CONCERNING THE CONSTRUCTION, USE AND MANAGEMENT OF STORAGE BATTERIES.

By A. RECKENZAUN.

(*Continued from page* 46.)

Resistance of a Secondary Battery.—The internal resistance of a storage battery is a variable quantity; it is least when the cell is fully charged, and most when the same is discharged, and it varies with the rise or fall of the specific gravity of the electrolyte. Sulphate is being formed on the lead plates during the discharge, and the same is again dissolved during the process of charging, consequently the strength of the sulphuric acid in a cell will vary continually, and it is possible to measure approximately the quantity of energy stored or withdrawn at any time by the specific gravity of the electrolyte. Results of extensive experiments made by the author upon this point will be discussed hereafter under the subject of sulphating.

The internal resistance of a cell can easily be calculated from the observed current, E.M.F. and external resistance by means of Ohm's law, $C = \frac{E}{R + r}$ where C represents the current in ampères, E the electromotive force in volts, R the known external circuit resistance, and r the internal resistance of the battery.

In Table I. we find the rate of discharge at 10 a.m. to be 46·65 ampères with 2·04 volts at the terminals, and an external resistance of ·0433 ohms; the internal resistance at this moment is approximately ·0004 of an ohm. At 12·45 p.m. the current dropped to 40·66 ampères, the E.M.F. to 1·87 volts, and the internal resistance rose to

$$r = \frac{1{\cdot}87 - 1{\cdot}74838}{40{\cdot}66} = {\cdot}00299 \text{ of an ohm,}$$

or over seven times the resistance calculated for the commencement of the discharge.

In Table II., again, with a current of 22·56 ampères at 9 a.m., an E.M.F. of 2·04 volts through an external resistance of ·089 ohms the internal resistance was nearly ·0004 with the cell fully charged. At 4 p.m. when the current dropped to 20·7 ampères and the E.M.F. to 1·9 volts with the same external circuit, the internal resistance rose to ·0028 of an ohm, exactly seven times that which was observed at the commencement of the discharge.

The resistance of a battery may be reduced by increasing the strength of the acid, but this cannot be carried beyond a certain limit, and this limit is determined by the minimum density requisite for the formation of a definite amount of sulphate; this internal resistance can also be reduced by placing the plates closely together (here, again, we are guided by a minimum volume of electrolyte); and finally the resistance can be reduced by increasing the surfaces of the plates, and this means enlarging the battery beyond the intended capacity. Therefore we are bound to allow a certain internal resistance, below which it would be difficult to go without sacrificing something else of greater importance, for, after all it must be admitted that the resistance of a well constructed secondary battery is exceedingly low in comparison with the circuit resistances usually connected with it.

Efficiency of Secondary Batteries.—M. E. Reynier, in a communication to the Physical Society of Paris, in May, 1881, ascertained the efficiency of storage batteries in the following manner:—Writing E for the E.M.F. of the battery, E_1 the E.M.F. of the charging apparatus, r the resistance of the accumulator, E_{11} the difference of potential at the lamp terminals, R the resistance of the external (lamp) circuit, R_1 the resistance of the charging apparatus, t the time of charge, t_1 the time of discharge, W the work expended by the charging apparatus, and P the useful work applied in the external circuit; then he argues algebraically thus:—

$$W = E_1 \frac{E_1 - E}{R_1 + r} t$$

$$P = \frac{E_{11}^2}{r + R}$$

then he assumes that

$$\frac{E_1 - E}{R_1 + r} t = \frac{E_{11}}{r + R} t_1$$

whence

$$t_1 = \frac{\frac{E_1 - E}{R_1 + r} t}{\frac{E_{11}}{r + R}}$$

Substituting for P, we obtain the equation

$$P = \frac{E_1 - E}{R_1 + r},$$

whence he obtains the efficiency

$$f = \frac{P}{W} = \frac{E_{11}}{E_1}.$$

Expressed in words, M. Reynier determines the efficiency by dividing the difference of potential at the lamp terminals by the E.M.F. of the charging dynamo; and he makes the efficiency independent of the resistances as well as of the time and current.

From a numerical example, where $E = 2{\cdot}15$; $r = {\cdot}006$; $E_1 = 2{\cdot}36$; $R_1 = {\cdot}006$; $E_{11} = 1{\cdot}93$; and $R = {\cdot}054$; M. Reynier obtains $f = \frac{1{\cdot}93}{2{\cdot}36} = 81{\cdot}8$ per cent.

The foregoing argument can only be accepted if the charge in ampère-hours equals the discharge in ampère-hours; such, however, has not as yet been found possible in practice; the time and the current density play as important a part in calculating the *efficiency* of a storage battery as the E.M.F's. The efficiency of a storage battery should be expressed independently of all external influences, such as circuit resistance, resistance of the generator, &c., and it is usual to ascertain it by the expression

$$f = \frac{c \times t \times E}{c_1 \times t_1 \times E_1},$$

where c_1 = the charging current, c = the discharge current, E_1 = the charging E.M.F. at the terminals of the battery, E the average E.M.F. of the cells when discharging with an average current, c; t_1 the time (in hours) of charging, and t = the time (in hours) of the discharge.

Examples: The current used for charging the cells (a) was 29 ampères, with an E.M.F. of 2·4 volts per cell; the time occupied in charging was six hours for both experiments I. and II. The discharge, however, of Table I. yielded an average current of 45·76 ampères for three hours, with an average E.M.F. of 1·964 volts, the efficiency, therefore, for this

$$= f = \frac{45{\cdot}76 \times 3 \times 1{\cdot}964}{29 \times 6 \times 2{\cdot}4} = {\cdot}645,$$

or 64·5 per cent.

The results of the test in Table II. were much higher; there we have with 22·34 ampères and 2 volts a steady discharge for seven hours, giving an efficiency of

$$\frac{22{\cdot}34 \times 7 \times 2}{29 \times 6 \times 2{\cdot}4} = 74{\cdot}9 \text{ per cent.}$$

Considering that the charging of these cells was effected at the comparatively high rate of 29 ampères, we must admit that an efficiency of 74·9 per cent. is exceedingly favourable; at a still lower rate of charging and discharging, and with more frequent readings, it is possible to obtain even higher efficiencies; but laboratory tests should not be taken as a basis of calculations intended for commercial purposes. We have already stated that a commercial efficiency of at least 70 per cent. may be relied upon in all cases where storage batteries

are used under normal working conditions, and this we propose to bear in mind at all times when prime costs, consumption of fuel, maintenance, depreciation, and kindred questions come to be studied in detail. Until recently it has been a matter of opinion with engineers as to the expense of an installation containing storage batteries. Manufacturers and others interested in the exploitation were apt to exaggerate the durability, efficiency, and other virtues of accumulators. Prejudiced opponents, on the other hand, denounced the storage battery not only as an expensive, almost useless, adjunct to an installation, but they predicted with emphasis that the storage battery could never become a commercially successful article. Among these prophets was Edison, the wizard of Menlo Park; perhaps he, like many others, has been converted by this time. We do not intend to convey the impression that the secondary batteries of the present day are perfection and incapable of further improvements; far from it, but we can now point to remarkable and economical results attained with storage batteries; results which compel us to keep our attention constantly alive, results which encourage us to renewed efforts in the direction of further improvement. Many have entered the field of competition, but astonishingly few have kept to it. It is all the more praiseworthy for the few survivors to have stuck to their difficult task; they find their perseverance rewarded. What we want now is a greater number of energetic men in the field, a healthy, honest competition, improvements which will lower manufacturing costs, more tools, more men, more factories to supply the ever increasing demand. We want to push new inventions which do not infringe existing rights, and these rights can easily be ascertained with precision. There is no need of treading on anybody's toes, the margin is wider than the uninitiated imagine; there is no chance of a monopoly excepting for those who are powerful and clever enough to produce the cheapest, most durable, and most efficient storage battery on lines different from their forerunners. The whole world is in need of accumulators, and there is room for plenty, if only a sufficient force devote itself with intelligence to one of the most interesting, and, at the same time, one of the most promising of modern industries.

(*To be continued.*)

POLARISATION OF RESISTANCE COILS.

In August last Professor Mendenhall, in conversation with the writer (Benjamin F. Thomas, in *Science*), alluded to his observation of the polarisation of certain resistance coils, and suggested an examination of the coils in this laboratory (Columbus, O.). The examination was made, and the results stated in remarks upon Professor Mendenhall's paper at the Buffalo meeting of the American association. A brief account may not be without interest and value.

The idea entertained by Professor Mendenhall at the time seemed to be that the polarisation was of a "statical" nature; the deflection obtained on connecting the coil, through which a current had been passed, with a galvanometer, being produced by the "residual charge." The examination of our coils was undertaken with the same idea, the "condenser discharge" method being made use of, substituting the coil under trial for the condenser. The galvanometer was a 6,000 ohm astatic Thomson, by Elliott Brothers, its needle making a vibration in about ten seconds. A Fuller cell and Sabine discharge key were used. Polarisation was found in every coil in the laboratory, except in a standard B.A. unit from Elliott Brothers. It was also found in a Hartmann box loaned for examination by Messrs. Queen & Co. The effect was found to vary widely in different coils in the same box, particularly so in a box of 100,000 units from Elliott's, whose 40,000 coil gave 40 degrees deflection against 6 or 7 degrees for any other coil in the box. On opening the box it was found that the 40,000 coil had been heated till the paraffin had melted and some of it had run off, while the other coils were well covered, as usual in Elliott coils. The Hartmann box, whose coils were not paraffined, showed the effect more strongly than any except the 40,000 Elliott. It was observed that the coil terminal connected to the positive pole of the battery in charging was itself positive in discharging; that reversing the battery reversed the discharge deflection; that the deflection was not momentary, as with condensers, but that it indicated a steady current, diminishing slowly, but not ceasing in some instances after eight or ten hours; that when the coil was charged by battery for several minutes, and then the current reversed and allowed to flow a few minutes longer, the discharge current was at first due to the last charging current, but after a time it ceased, and was followed by another discharge current due to the first charging. An experimental coil was then made up of 1,800 ohms of wire having unparaffined cotton insulation. It was wound on a warm rainy day, and tested immediately, showing the strongest polarisation found, driving the spot of light violently off the scale. The coil was then baked in a hot air oven at 150° C. for an hour, and tested again when cool. No trace of polarisation could then be found, though the charging current was increased. The previous observations of course indicated electrolytic polarisation as the disturbing cause; and the last showed that, in the case of that coil, it was electrolysis of water absorbed from the air by the cotton insulation. The experimental coil was then heated and soaked well with pure paraffin, and drained while hot until it seemed to be as nearly as possible in the same condition as the 40,000 Elliott coil, and tested when cool. No trace of polarisation was shown. It was then put aside in the instrument case to see whether it could still absorb water enough to polarise. Ten days later, just after the Buffalo meeting, the coil was tested again and polarised strongly. On heating it again the polarisation entirely disappeared. A drop of hydrant water placed on the coil caused polarisation to re-appear in five seconds, and in five minutes the effect was so strong as to drive the needle to its stops.

The degree of error in measurement resulting from polarisation was not examined, but Professor Mendenhall's statements show that it may be a considerable quantity.

It is obvious that unparaffined coils are, on this account, unsuited to the best work; also that coils well paraffined (as in the B.A. unit coil) or coils freshly baked and paraffined are free from such error.

The paraffining of ordinary coils, even when as thoroughly done as by the Elliotts, is not a permanent protection, probably because of cracking of the mass of paraffin, allowing vapour to reach the wire and insulation. A test will quickly determine the condition of any particular coil. A box might be made proof against polarisation by filling entirely the space about the freshly baked coils with pure paraffin, just warm enough to flow freely. Temperature difficulties could be in part overcome by the thermo-junctions, as in standards. Another, and on some accounts better, plan would be to mount the coils in an impervious box with liquid-tight joints, and filling the interior with a petroleum oil, which may readily be found in market, of such quality as to exhibit no polarisation. With such a box, there need be no uncertainty as to the temperature of the coils.

INCANDESCENT LIGHT LEADS.*

By CARL HERING.

As incandescent lamps are connected in multiple arc, and as they require to have a constant potential at their poles, there must in all cases be a higher potential at the machine, and a loss of potential in the leads.

* *The Electrician and Electrical Engineer.*

As this loss of potential depends on the resistance of the leads and the current in them, it remains constant only for the same resistance and current, and, therefore, when the lamps are cut out the current will change and consequently also the potential, or, in other words, the lamps will have their potential increased when their number is reduced, and *vice versâ*.

The only ideally perfect method of running incandescent lamps, therefore, is to have a pair of independent leads from each separate lamp to the dynamo, and to have them all of the same resistance, in which case the cross-section will be increased directly as the distance, that is, for double the distance the leads will have double the cross-section, or four times the weight. This will evidently be a perfectly self-regulating system, but it would in most cases be too expensive, as for 100 lamps there would be 200 leads. There is, however, one important point about such a system which is greatly in its favour. There are two expenses to be considered, one the cost of the power lost in the leads and the other the interest on the copper conductors; both of these are running expenses. If we start with very heavy leads and calculate these two expenses for successive diminutions in the size of the leads, we obtain the results about as shown by the two curves in fig. 1. The upper curve is the interest

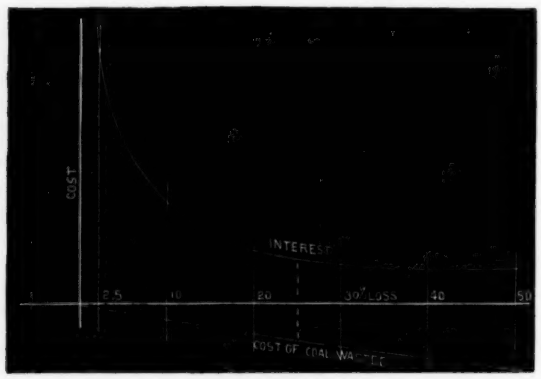


FIG. 1.

on the copper for different losses in the leads, and the lower, which is a straight line, the cost of the lost power. The sum of the two, that is, the distance between them, represents the total expense, which in this particular case was least when the loss of potential in the leads was about 22 per cent. This result may at first be surprising, but it will be seen that the power expense is very small as compared to that of the copper. If the lamps are burned only a small portion of the day, the loss of potential may even be taken still greater as the interest is for the full time and the duration of the power loss is less. In the ordinary system such a great loss in the leads cannot be allowed, as it would not be self-regulating when lamps are cut out.

In cases where all the lamps are always in circuit, such a heavy loss may safely be allowed even in the ordinary system, thus effecting a great saving in expense, both first cost and running; it is necessary in that case to replace a lamp as soon as it goes out, otherwise the others will soon all follow in turn. In cases where whole groups of lamps are cut out at one time, a separate pair of mains may be laid to each group from the dynamo, and the system will then be self-regulating, while the loss in the leads may be taken as quite great, say 15 to 20 per cent., thus saving considerable copper.

In the ingenious system of Gordon's divided main, from a description of which fig. 4 was taken, this principle of small mains is made use of by dividing the main from the dynamo to a point in the midst of the lamps into a number of smaller insulated mains, which are in turn cut out at the dynamo end as the lamps are cut out, thus accomplishing practically the same results as those of the method first described. Perfect regulation, and great saving of expense may thus be accomplished.

The next best way to ensure approximate regulation of constant potential at the lamps, is to make the conductor so thick that the fall of potential will be so small that its variation will be insignificant. This is the ordinary method in which the loss of potential allowed may be 2, 3, and even 4 or 5 per cent., the latter only in cases where the leads are well distributed with reference to the lamps. In such a system a pair of mains should be laid from the dynamo to near the centre of the group of lamps to be supplied by these mains, and from this point only, should the branch or distributing wires be laid to the lamps. These distributing wires should all be calculated for the same loss of potential, and should therefore be thicker the farther the lamp. In a good system it is preferable, when distances are great, to run separate distributing wires to each group, as in fig. 3, in preference to running one secondary pair of mains from which lamps are supplied at various distances, as in fig. 2.

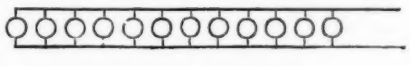


FIG. 2.

When lamps are situated near the course of the principal mains, it is preferable, when distances are great, and when a comparatively great fall of potential is allowed, to run a pair of distributing leads from the ends of the mains back to the lamps, rather than to connect the lamps directly to the mains, or else to use comparatively high resistance distributing wires direct from the nearest point on the mains.

In this system the mains are generally very large, and in order to facilitate laying and handling, it is generally found preferable to use a number of thick wires in parallel. These separate wires usually have their ends permanently connected with each other at the distribution centre. But as will be seen by comparing this system with the one first mentioned, a much better distribution may be had with these same parallel wires by connecting each one to a separate independent group of lamps, instead of connecting them all with one another at the distribution centre. The increase of potential due to cutting out lamps is

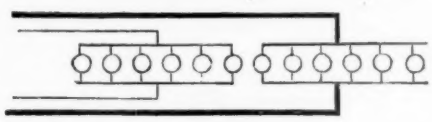


FIG. 3.

then much smaller than if the parallel wires act as one main; it approaches more nearly to the so-called perfect system.

The practice of having lamps requiring slightly different potentials, for different distance along the mains, is not good, except where the groups are entirely distinct and separate, as in different buildings for instance, and even then it is preferable, if not essential, to have separate independent mains from the dynamo to each group.

In cases where there are many lamps between two parallel mains, as in fig. 2, it is bad practice to diminish the size of the leads toward the end, when the distances are great; it should, on the contrary, be increased, or at least be equally large, in order to approximate to constant potential. When in this case the number of lamps is large, it is preferable to run several pairs of mains to successive groups, making the longer mains thicker, as shown in fig. 3.

A very good system, which, however, is limited in its application owing to the position of the lamps, is to run the mains as shown in fig. 4. The fall of potential, or resistance of the leads, will evidently be constant

for each lamp as long as they are all burning, but for variations in the numbers of lamps it is only approximately self-regulating like the others. When all lamps are always in circuit, this system permits of great saving of copper, at the same time giving equal potentials, when the loss of potential allowed is considerable, say 15 to 20 per cent.

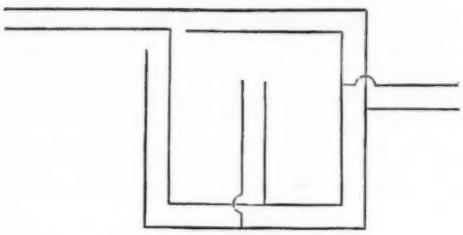


FIG. 4.

In cases where a single pair of mains is laid from the dynamo to a distributing centre at some distance from the machine, a considerable saving of copper may be effected and at the same time some power saved, if the potential is maintained constant at the distributing centre, but increased at the dynamo proportionately to the number of lamps burning. In this case the mains may be made small, and the loss in them comparatively great; the percentage of power lost in the mains then evidently decreases with the number of lamps. This system is even better than the first one described and termed the ideally perfect system, provided the leads are well distributed from the ends of the mains, as it saves more power and requires only one pair of mains for the greater part of the distance, instead of a large number of separately insulated small wires. It is, however, limited in its application to special cases, in which a group of lamps is at a comparatively great distance from the machine, and only one such group can be supplied by a machine. Furthermore, the machine has to be regulated to increase its potential in a certain proportion with the current. This can readily be done in compound machines, if the series windings be increased sufficiently to make this difference. If the machine is regulated by hand or by an automatic regulator, a pair of small return leads may be laid from the distributing centre back to the regulator, the potential of these wires, that is, that at the distributing centre, must then be maintained constant, and that at the machine, therefore, increased.

To illustrate this method of distribution by an example, let us suppose 150 lamps of 100 volts and ·6 ampères, to be run in a group at 2,000 feet from the machine. Assume first a loss of potential of 25 per cent. in the mains; the greatest potential at the dynamo will therefore have to be $\frac{100}{\cdot 75} = 133$ volts; that is, there will be 33 volts lost in the mains. As the greatest current is $150 \times \cdot 6 = 90$ ampères, the resistance of the mains must be $\frac{33}{90} = \cdot 37$ ohms, and as the length is 4,000 feet, it will require about a No. 0, B. and S. wire. When only one lamp is burning the fall of potential will be $\cdot 6 \times \cdot 37 = \cdot 22$ volts, making the potential at the machine practically 100 volts, and the variation from 100 to 133 volts. The mains will not heat too much as this wire will carry 90 ampères without danger. To compare this with the ordinary method, allow say 4 volts or 4 per cent. loss in the mains; the resistance will have to be $\frac{4}{90} = \cdot 0444$ ohms for 4,000 feet, or in other words, it will have to be 9 times as great in cross section, that is, 18 wires, size 0, or an increase of 16 lengths of 2,000 feet each, above what was required in the first case. The interest per day on this additional amount of wire and on the cost of laying it, will be found to be slightly greater than the extra cost of the excess of power lost in the first case over that lost in the second, that is the difference between 25 per cent. and 4 per cent. Better regulation will be effected for the smaller mains than for the larger ones, provided the machine regulates well; for in the latter case the potential will vary 4 volts at the distributing centre, while it will be constant in the former. The best proportions will vary for different circumstances, and should therefore be determined for each case. The smaller mains will be more economical for greater distances, and *vice versa*.

The three-wire system is well known to all. It is limited in its application to cases in which the two groups of lamps are always nearly equal; if, for instance, all the lamps of one group, that is between two of the three mains, be turned off, the fall of potential will be very great, and the regulation very bad.

Another system which is quite similar to this one, but has the advantage that only one machine of double the potential is required, instead of two as in the Edison three-wire system, is used by the Keystone Company in their central station plant in Philadelphia. It is shown in fig. 5. A compensating group of lamps is kept at the station, and is so connected that it can

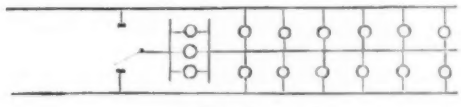


FIG. 5.

be switched into either side of the equalising lead, thus restoring the balance. This is not automatic, and therefore requires constant attendance.

Numerous rules, formulæ and tables have been published, for determining the size of leads for incandescent lighting, most of which, however, are more or less complicated, and will therefore find limited use in practice, the natural result of which is, that instead of properly determining the leads the engineer will use his "judgment" in selecting the sizes, which is little short of guessing. In cases where tables are used considerable calculation is necessary to make the tables, and a new set has to be made for a lamp of a different current or potential.

In order to meet the demands of good engineering practice, which are: reliability of the method, labour saving in the calculations, accuracy of results, flexibility and simplicity of the method, and freedom from errors of complicated calculations, the writer has devised the following method, which is found by extended experience to answer all these requirements.

As described before, the leads must be calculated for a certain allowable loss of potential in them. This is ordinarily from 2 to 5 per cent., the greater of which should be allowed only when the number of lamps cut out at any time is not a very large proportion.

Let V be the number of volts lost in the leads,
R the resistance of the leads,
C the current in them,
A the cross sectional area of the lead in square mils,
L the length in feet of the whole lead.

Then $$C = \frac{V}{R} \text{ and } R = \frac{L}{A}\ 8{\cdot}22$$

from which the general formula is deduced, namely:

$$A = \frac{C\ L}{V}\ 8{\cdot}22,$$

or if D is the distance from dynamo to lamps, in which case $L = 2\ D$, then

$$A = \frac{C\ D}{V}\ 16{\cdot}44.$$

This formula is quite general and is applicable to all lamps or losses of potential. The constant 16·44 is not an arbitrary one, as is sometimes supposed, but depends only on the resistance of the copper, as shown above.

In practice this formula would be used in a simpler form, as we may substitute for C the number of lamps, n, multiplied by the constant current, c, for one lamp, and as the loss of potential is a constant for a certain

installation, it may be combined with the constant, 16·44, thus giving the simple form

$$A = n\,d\left(\frac{16{\cdot}44\,c}{v}\right)$$

in which the latter quantity is calculated once for all. Thus the cross section is the number of lamps multiplied by the distance in feet and by a constant. For 4·11 volts loss of potential, and ·75 ampères per lamp, this reduces to

$$A = 3\,n\,d\,;$$

that is, the lamp distance, or lamp feet multiplied by three is the cross section. By means of a table of cross sections of the different sizes of wire, such as every electrician has, the diameters or gauge numbers may be found directly without calculation from the cross sections. It is especially convenient when several wires are to be used in parallel.

The formula might be made to give the diameter directly, but this is not to be recommended, as it involves a square root calculation which is objectionable except for single cases.

In cases in which a great fall of potential is allowed, in which the wires will heat slightly, the resistance constant, 8·22, must be taken slightly higher. In most of such cases it will suffice to take the cross section slightly greater than that given by the formula, instead of changing the constant.

In general, the mains lead to a distributing centre, and should, therefore, be calculated separately for a certain part of the loss of potential, while the distributing leads should be calculated for the rest of the loss. If a portion of the lamps are at a considerable distance from this distributing centre, they should have a separate independent sub-main from the distribution point, which will then allow the same fall of potential for these lamps as for all the others. There is no reason other than economy of copper why the distant lamps of a group should not have the same potential as the rest, and be maintained as nearly constant as the rest.

For calculating the size of leads the ordinary mechanic's slide rule may be very highly recommended, as by means of it the computations may be made in almost the same time as it would otherwise take to write down the figures, while the chances of making a mistake are not nearly as great as in the ordinary calculation, unless it is checked. Even the diameter can then be readily found with but a very slight additional adjustment of the slide, thus avoiding entirely the use of any tables.

When many computations have to be made, as for instance in a somewhat complicated system of distribution, the following graphical method will be found not only to save considerable time, but also to reduce to a great extent the probability of an error in the calculation. On a piece of accurately prepared cross section paper (the decimal lithographed preferred to the ruled), mark the figures and lines as shown in part in fig. 6. A convenient size is about 18 inches high and 2 feet long. In the first vertical column mark off, to a convenient scale, the cross sections embracing the range of wires used for leads. In the next column mark off the sizes of the wire in numbers of the gauge used, corresponding to their proper areas of cross-section in the first column, as obtained from a table. In a third column may, if desired, be laid off similarly the diameters of the sizes of wire obtainable, in the proper places with reference to the first column. These three columns will then correspond to a table of cross-sections, diameters, and gauge numbers. Through the points of the second column, and any in the third corresponding to sizes used, draw bold horizontal lines. On the upper side of the paper mark off in ten-thousandths, numbers ranging from 1 to about 200,000.

For the particular lamp for which the scales are to be made, calculate, from the formula, the required cross-section for any fixed number of lamps at any fixed distance, for a loss of potential of 10 per cent. Mark off this point, a, in its proper position, considering the figures in the horizontal scale to represent lamp-feet, that is number of lamps multiplied by the distance to the dynamo in feet. Draw a straight line through this point and the zero point. Similarly, draw the other radial lines corresponding to the other percentages of loss to be used, which can be done best by dividing the horizontal distance from the first line to the zero line into ten parts, and drawing a radial line through each one, thus each will represent one per cent. loss, as shown. If greater loss of potential is allowed, the corresponding lines should also be drawn. It is then ready for use.

To use it, multiply the number of lamps by the distance, find this number on the horizontal scale and follow it to the radial line which represents the percentage of loss; the cross-section, diameter, or gauge number is then found directly from the numbers in the vertical columns corresponding to the position of this point.

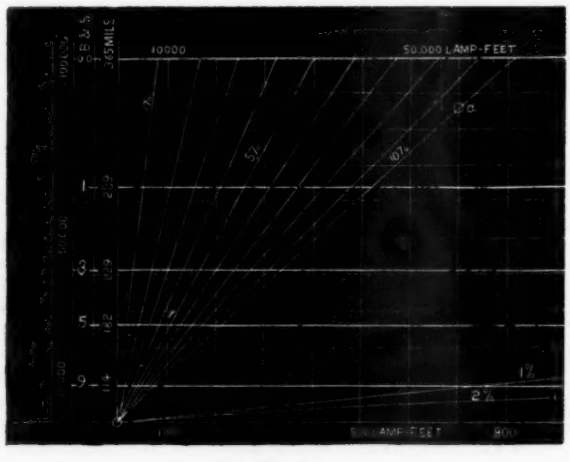


FIG. 6.

Such a graphical method will be found to save very much time, particularly when it is desired to make the estimate for several different systems of distribution, in order to find the most economical one. It is free from the errors which are liable to occur in tables, and takes only a very short time to prepare. Its range may easily be made very great, thus corresponding to a very large set of tables, which would require much time to prepare.

The point for determining the radial line should be chosen as far from the zero point as possible, in order to locate the line as accurately as possible.

In order to increase the accuracy for a small number of lamp-feet, that is, for the small distributing wires, a second horizontal scale of smaller numbers may be laid off, say at the bottom, and a second set of radial lines, drawn say in a different colour, may be determined for these numbers. For still other ranges the cross-sections may be supposed to represent 10 or 100 times those in the column, and the corresponding scale of lamp-feet be found for the radial lines already drawn, in which case the figures should be marked in a distinct colour in order to avoid confusion. In that case the diameters and gauge numbers will no longer correspond with those new cross-sections.

Motive Power for Industrial Purposes at Genoa.—A project for supplying motive power for lighting Genoa by electricity, according to *Industries*, has lately been advocated. It is proposed to construct an aqueduct from the Tanaro, near Garessio, in the province of Cuneo, passing through the Apennines by a long tunnel and series of important works to Loano, a little town on the Ligurian coast, when the water power would be used during the day for a large metallurgical works which would be established there. The cost of this work is estimated at £280,000, and the available power at 10,000 H.P.

ON SILK v. WIRE SUSPENSIONS IN GALVANOMETERS, AND ON THE RIGIDITY OF SILK FIBRE.

By THOMAS GRAY, B.Sc., F.R.S.E.*

IN the last number of the *Philosophical Magazine* there is a short article by R. H. M. Bosanquet drawing attention to some eccentricities of a galvanometer used by him. A determination of the rigidity of the suspending "fibre" of the galvanometer needle would have been interesting, as it would have thrown considerable light on the probability or improbability of the explanation offered. It must have caused no little surprise to many of the readers of the *Philosophical Magazine* to find that Mr. Bosanquet based his condemnation of silk fibre suspensions on the trouble he experienced with an instrument the suspending fibre in which was "left just stout enough to carry the weight," and which was of such a nature that it could possibly *twist* or *untwist* with stretching or with hygrometric changes in the atmosphere. Surely Mr. Bosanquet is scarcely in earnest when he writes about suspending the needles of a sensitive galvanometer with a *twisted* silk thread, or when he proposes to go back something like half-a-century in the history of this subject†, and adopt galvanometers with needles seven inches long made of stout knitting needles and suspended by a wire five feet long.

A galvanometer needle should never be so heavy that it cannot be suspended by a *single* fibre of silk (that is, *half an ordinary cocoon fibre*), because such a fibre will bear easily, leaving a good margin of safety, two grammes; and it is an easy matter to so arrange such a mass that the period of vibration will be not only so much as thirty seconds, but even several minutes. With an astatic arrangement, especially if it be only "nearly astatic," there will be changes of zero certainly, but I can hardly see anything comparable to a "ghost" in what could occur.

About a year ago I made, in the Physical Laboratory of Glasgow University, a number of experiments on silk fibres, which included among other things some determinations of their rigidity. Mr. Bosanquet's paper has suggested to me that possibly a few of the results may be worth publication. Some of the results of these experiments are in type in vol. iii. of the reprint of Sir W. Thomson's mathematical and physical papers now in the press.

Two methods were used for the determination of the rigidity. The first method was almost identical with that introduced in this laboratory 35 years ago by Sir W. Thomson, and now commonly adopted for the determination of the rigidity of metallic wires. It consisted in suspending from a fixed support, by means of a measured length of the fibre, a thin circular rim of non-magnetic material and of easily calculated moment of inertia, and observing the period of the torsional vibrations. From this the torsional rigidity of the fibre can be readily calculated by a well-known formula. The second method consisted in suspending a small mirror, to which was rigidly fixed a small magnetic needle of known magnetic moment by means of a measured length of the fibre, and observing the deflection of the mirror produced by twisting the top of the fibre through a measured angle. This gives a ready means of calculating the rigidity of the fibre in terms of the magnetic moment of the suspended needle, and the strength of the magnetic field in which it is suspended.

The fibres were of Japanese floss silk, which had been thoroughly washed in hot water to remove the gum which is always found in considerable quantity on cocoon fibres. The fibres were in all cases single fibres; and it will be seen, both from the direct measurements by the microscope and from the rigidity, that they vary considerably in thickness. Even a rough estimate of the rigidity per square centimetre section of the substance is impossible, as the fibre is not even approximately circular in section, and its diameter not nearly regular along its length. The results of the experiments are given in the following table, the headings of the different columns being sufficiently explanatory of the numbers.

VIBRATOR METHOD.

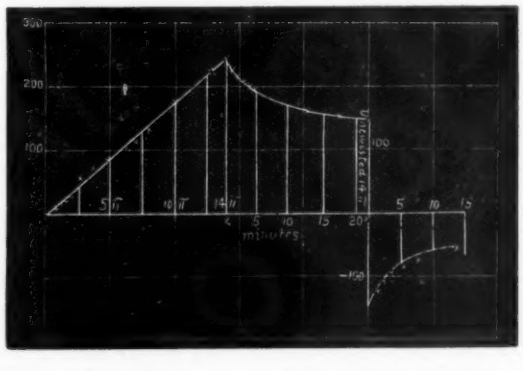
Mass of vibrator, in grammes.	Radius of gyration of vibrator, in centimetres.	Length of fibre, in centimetres	Diameter of fibre, in centimetres	Period of vibrator, in seconds.	Torsional rigidity, in C.G.S. units, of a length of 1 centim. of the fibre.
0·0274	0·20	8·60	0·0008	29	0·00096
0·0114	0·29	8·60	0·0010	16	0·00132

MAGNETIC METHOD.

Length of fibre, in centimetres.	Diameter of fibre, in centimetres.	Deflection per turn of torsion head on a scale of millimetres. Magnetic field = ·155.	Distance of the scale from the mirror, in centimetres.	Torsional rigidity, in C.G.S. units, of a length of 1 centim.	Young's modulus for the fibre, weight in grammes.*
9·05	0·0010	8·0	117·0	·00143	75·4
9·20	0·0009	8·0	117·0	·00090	61·3
8·45	0·00145	21·0	117·0	·00216	65·6
9·55	0·0015	21·5	117·0	·00250	73·5

* This is the ratio of the product of the pull applied to the fibre, and the length of the fibre, to the elongation produced by the pull, or, if E be the modulus, $E = \frac{\text{weight applied} \times \text{length of fibre}}{\text{elongation}}$.

The following curve illustrates an experiment, and shows how nearly proportional the first deflection is to the torsion even after the elastic limit of the



fibre has been far exceeded. In the first part of the curve the ordinates are the scale-readings, the abscissæ the angle turned through by the torsion-head, which we may, without appreciable error, assume to be the torsion of the fibre, as the angle turned through by the mirror is so small as to be negligible; in the last part the ordinates have the meaning, but the abscissæ indicate time. This second part of the curve shows the rate at which the fibre takes a set under the torsional stress; the part of this curve below the zero line shows the working out of the set after the fibre was untwisted. The length of the fibre in this experiment was 8·5 centim. and the average thickness about 0·0015 centim.

When a galvanometer is made sufficiently sensitive for the fibre to play an important part in directing the needle, the set of the fibre due to continued deflection always produces an apparent change of zero which, in exact measurements, it is somewhat difficult to properly allow for. Except, however, in very special cases, as, for instance, in taking deflections with a Thomson's "dead-beat" galvanometer in a weak mag-

* Communicated by the author to the *Phil. Mag.*

† Some interesting experiments "On the Suspension of the Magnetic Needle by Spiders' Fibre" are described by the Rev. A. Bennet, F.R.S., in the R. S. Trans. vol. lxxxii. 1792.

netic field, the error is small, and it is not in any way capricious. It is important to bear in mind, however, that for very sensitive galvanometers to be used as deflectional instruments the suspension should be of considerable length, such, for example, as is provided in the Thomson's astatic galvanometer.

From the data given above we may very easily form an estimate as to when the rigidity of a silk fibre comes to be an important factor, affecting the sensibility of a galvanometer. If C be the current flowing through the galvanometer, K a constant depending on the coils, I and I′ the field at the upper and lower needles respectively, m and m' the magnetic moments of these needles, τ the torsional rigidity of the fibre, and θ the deflection, we have

$$C = K \left\{ \frac{I\,m - I'\,m'}{m + m'} \tan\theta + \frac{\tau\,\theta}{(m + m')\cos\theta} \right\}.$$

When the needle system is perfectly astatic, $m = m'$, and this reduces to

$$C = K \left\{ \frac{I - I'}{2} \tan\theta + \frac{\tau\,\theta}{2\,m\cos\theta} \right\};$$

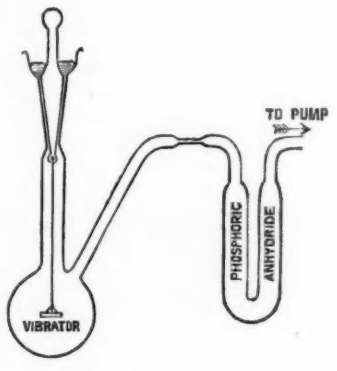
and for small deflections this may, without great error, be written

$$C = K\,\theta \left\{ \frac{I - I'}{2} + \frac{\tau}{2\,m} \right\}.$$

From this equation we see that the fibre becomes important when $\frac{\tau}{m}$ is not small compared with I − I′. Now in a very sensitive instrument it is not unusual for I − I′ to be reduced to about ·001, and m in such an instrument as we are considering will not differ much from unity. Hence τ must be much less than ·001; and we find, from the tables given above, that, for a fibre of about the usual length, say 5 centim., τ will be about ·0003; or about one fourth of the total force is, in this case, due to the fibre. This, then, may be taken as about the limit of sensibility beyond which we cannot easily pass with an ordinary Thomson's astatic galvanometer with small needles; to get beyond it, attention must be directed to an increase of m*. The limit here indicated is, however, far beyond anything that can be reached with wire suspension, the smallest current which can be measured being about 10^{-9} ampères for a galvanometer of 1 ohm resistance, and about $0{\cdot}2 \times 10^{-10}$ ampères for one of 10,000 ohms resistance. When I − I′ is as much as 0·01, or between a tenth and a twentieth of the earth's horizontal force in this country, the effect of the set of the suspending fibre is extremely small. With such a value of I − I′, however, a properly constructed galvanometer, the resistance of which is as low as 1 ohm, will measure a current of 10^{-8} ampères. When very high sensibility is absolutely necessary, it may be to some extent obtained by increasing the length of the fibre; but if this prove insufficient, some alteration or other arrangement of the parts becomes necessary. Such an arrangement is described in the paper referred to in the footnote; but it may be remarked that, in so far as this arrangement is intended to increase m, it is only important when I − I′ is made practically zero. So long as I − I′ is considerably greater than τ, a high value of m is of no importance; and the Thomson form is, because of the small inertia of its needle system, decidedly the best.

NOTE.—Since the above was written Mr. J. T. Bottomley has suggested to me that some interesting results might be obtained if the vibrational method, above referred to, were carried out with the fibre and vibrator in a good Sprengel vacuum; and in conjunction with him I have made some preliminary experiments, the results of which seem worth quoting.

The vibrator used was the lighter of the two referred to in connection with the former experiments, and consisted of a small ring of brass 0·295 centimetre radius and 0·012 gramme in weight. It was suspended, as shown in the diagram, inside a small spherical bottle provided with a long neck and a ground stopper, to the lower end of which the fibre was attached. A tube passed from the side of the bottle to one end of a U tube, containing phosphoric acid and beads of glass, the other end of which was sealed to a tube leading to the Sprengel pump. The vibrator was attached to the



fibre by means of three short single fibres, in the manner shown in the sketch. The results are given in the following table, the meaning of the numbers in the different columns of which will be readily understood from the headings. In the column headed "numbers of vibrations observed" the figures represent roughly the number of periods which could be observed at the different degrees of exhaustion, shown in the preceding column, beginning in each case from an amplitude of about 60°, and observing directly the transits of a black spot on the ring over a fixed mark until the amplitude fell to about 10°.

The results are sufficient to show that the effect of the viscosity of the fibre in damping the vibrations is very small in comparison with the effect of the air friction; and it seems probable that a moderately heavy vibrator (say about 2 grammes in weight) with a small magnetic needle attached, and suspended by a single silk fibre, may prove a good arrangement for experiments such as have been carried out by Maxwell, Kundt and Warburg, Crookes and others on the friction and viscosity of gases. It certainly would have the advantage that the period would depend mainly on the strength of the magnetic field, and could be varied at pleasure. Should opportunity offer, Mr. Bottomley and the writer hope to continue these experiments.

Number of experiment	Length of fibre, in centimetres.	Diameter of fibre, in centimetres.	Period of vibrator, in seconds.	Pressure of air at the vibrator, in atmospheres.	Numbers of vibrations observed.	Torsional rigidity of fibre per centimetre of its length in C.G.S. units.
1	3·9	·00095	10·5	1·00	7	
,,	,,	,,	9·6	$1{\cdot}46 \times 10^{-3}$	14	·00134
2	3·7	·00120	7·78	1·00	7	
,,	,,	,,	7·64	0·066	7	
,,	,,	,,	7·42	$1{\cdot}46 \times 10^{-6}$	(?)	
,,	,,	,,	7·42	$0{\cdot}40 \times 10^{-6}$	60	·00261
3	3·65	·00105	12·5	1·00	5	
,,	,,	,,	11·92	$7{\cdot}45 \times 10^{-3}$	7	
,,	,,	,,	11·83	$8{\cdot}35 \times 10^{-6}$	15	
,,	,,	,,	11·63	$0{\cdot}53 \times 10^{-6}$	40	
,,	,,	,,	11·57	$0{\cdot}13 \times 10^{-6}$	50	
,,	,,	,,	11·61	$0{\cdot}13 \times 10^{-7}$	50	·00110

Electric Locomotion a Great Blessing.—In editorial comment on the Julien storage street car system, *Building* says:—"It would seem as if this system of moving the street cars would certainly prove a great blessing to this or any other great city, if it did nothing more than diminish the number of horses on our streets."

* On this subject see a paper "On a New Reflecting Galvanometer of Great Sensibility," by T. and A. Gray, Proc. Roy. Soc. No. 230 (1884).

THE TELEGRAPH IN 1886.

OUR contemporary the *Journal Télégraphique* has in its issue of January 25th, a very interesting article on the advance made during 1886 in the application of electricity. It treats of submarine cables, land lines, the telephone, various inventions, electric lighting, transmission of power, electric railways, &c., and gives a list of the most important publications on electrical subjects. A *resumé* of the part referring to the telegraph and the telephone may be of interest.

One of the most important events in 1886, from a telegraph point of view, was the bringing into effect the principle adopted at the Berlin Conference of 1885 of the word rate, pure and simple. It is as yet too early to judge as to the results of the change of system. The effect up to the present has been a considerable reduction in tariffs generally.

It is to be hoped that submarine cable companies will find it possible to arrive at some mutual arrangement by which a steady and progressive reduction of rates may be attained. The present keen competition in trans-Atlantic telegraphy has brought about a war of rates which, while temporarily beneficial to the public, is at the same time disastrous to the companies engaged in it, and must eventually turn out disadvantageous to the public.

The greatest development in submarine telegraphy has taken place along the West Coast of Africa, where the Silvertown Company has laid some 2,916 nautical miles of cable for the West African Telegraph Company, and 661 nautical miles for the African Direct Company; the Telegraph Construction and Maintenance Company has, on the same coast, and for the Direct African Company, laid some 2,078 nautical miles of cable.

Among the operations of less importance, the English Post Office has laid a 4-conductor cable of about 55 nautical miles in length between England and Ireland; two cables, each with three conductors, and 8 nautical miles long, have been laid across the straits of Messina; and some short cables along the coasts of Germany, Austria, and Holland complete the submarine work for 1886. There are, however, many schemes, some of large proportions, and more or less developed. Noticeable among them are a Pacific cable between the Continent of America and Australia; an Atlantic cable *viâ* the Azores and the West Indies; the Halifax Bermuda and Jamaica cable; a direct cable between Great Britain and Australasia; a direct cable between North and South America *viâ* New York, Hayti, Venezuela, Cayenne, and Pará; and, finally, the cables between the East Coast of Africa and Madagascar, Maurice, and Réunion *viâ* Zanzibar and Mozambique, for which undertaking it is rumoured that an annual subvention of 75,000 francs has been offered.

The most noticeable increase in the development of land lines has taken place in the United States, where the system has been wonderfully augmented in a westerly direction; in Canada, where no doubt the successful carrying out of the Pacific Railway has given an impulse to telegraphy; in Brazil, where the land line system has reached Pará, the northern extremity of the submarine cables along that cost; in Russia, where the land lines have been extended to the Chinese frontier; in China, where during 1886 forty-one new telegraph stations were opened; the opening of the Moulmein line, by which a duplicate communication between India and Siam is obtained; and the establishment of the telegraph system in Perak.

It is to be hoped that in the course of the present year the enactments proposed and discussed at the meetings of the Conference for the Protection of Submarine Cables will be definitively adopted, and that the French Administration will at last have the satisfaction of seeing a legislation which it was the first to propose and which it has so earnestly supported, universally placed in force.

Among the details of telegraph work, the most noteworthy features were the great extent to which iron wires have been replaced by phosphor and silicon-bronze; the very considerable employment in Great Britain of Delany's multiplex system; the adoption to a large degree, by the French Administration, of the Estienne instrument as lately perfected; and the great attention attracted to the steno-telegraphic apparatus of M. Cassagnes.

The inventive spirit has, however, principally shown itself in improvements to, and advance in, telephonic appliances. The telephone has become an international means of communication, for it is now used between Germany and Switzerland, France and Belgium.

Van Rysselberghe's experiments on the simultaneous employment of the telegraph and telephone on the same wire have resulted most satisfactorily, and it is reported that the same idea has been successfully carried out in the systems introduced by Cardew and Langdon Davies.

INCANDESCENT LAMP PATENTS.

EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY *v.* WOODHOUSE AND RAWSON.

Monday, January 31st, 1887.

IT will be remembered that the appeal in the case between the above parties upon the Edison patent of November 10th, 1879 (No. 4,576), for the invention of and improvements in electric lamps, was argued before Lords Justices Cotton, Bowen and Fry, on December 13th and following days. The appeal was from the judgment of Mr. Justice Butt, delivered on May 20th of last year, which was to the effect that the patent of the plaintiffs was valid, and had been infringed by the defendants.

Sir Horace Davey, Q.C., Mr. Macrory, and Mr. H. G. Rawson, were for the appellants; and the Attorney-General (Sir Richard Webster, Q.C.), Mr. Aston, Q.C., Mr. Fletcher Moulton, Q.C., and Mr. P. Edward Dove, were for the respondents.

Judgment was delivered on Monday last, Lord Justice Fry reading the judgment of himself and Lord Justice Bowen supporting the decision of the judge below, and Lord Justice Cotton giving his opinion independently, differing from his learned brothers. The majority of the court being in favour of that course, the appeal was dismissed.

LORD JUSTICE FRY: By the request of Lord Justice Bowen I am about to read, in the first place, the judgment of Lord Justice Bowen and myself, and not that of Lord Justice Cotton. The plaintiffs in this action are the assigns of letters patent, dated November 10th, 1879, and granted to Mr. Edison for the invention of and improvements in electric lamps, and in the method of manufacturing the same. The defendants are manufacturers of electric lamps, and are sued for an infringement of the patent. Mr. Edison's object, as stated in his specification, was to produce electric lamps, giving light by incandescence, which lamps should have high resistance, so as to allow of the practical sub-division of the electric light. Mr. Edison, in his specification, proceeds to state of what his invention consists. The first element in his invention is the coiling or arranging a light-giving body of carbon wire or sheets, so as to make the resistance high in proportion to the light-giving surface. The second element was the placing of the light-giving body in a nearly perfect vacuum. The third element was the conducting of the current into the vacuum bulb through platina wires sealed into the glass. The fourth element was the mode of manufacturing carbon conductors. The fifth element was the mode of securing perfect contact between the metallic wires and the carbon. After some statements as to the existing state of knowledge and invention, the patentee proceeds in his specification to describe the mode of carrying his invention into effect. The description is so far from being as clear as it might be that we at one time doubted whether it was not studiously and wilfully obscure, but on further consideration we are not prepared to hold such to have been the case, especially as the point was not urged by the appellants. It is not needful for us to pursue the description of all the processes given by the specification; but we will refer to the forms of carbon conductor described. The first form referred to as suitable is "cotton thread properly carbonised," which is stated to offer from 100 to 500 ohms resistance to the passage of a current. The second form of conductor referred to is any fibrous vegetable substance which will leave a carbon residue after heating in a closed chamber. To this class may be referred the "cotton and linen thread, wood splints, and paper coiled in various ways," to which Mr. Edison refers. The fourth form is "such fibrous material as beforementioned rubbed with a plastic compound of blacklead and tar. The fifth form is a carbon filament made of a combination of tar and lampblack, or plumbago or carbon in other forms, the tar being subsequently carbonised by being subjected to high heat in a closed chamber. (Page 4 of specification, lines 1 to 40.) Mr. Edison observes that small pieces of such a compound may be rolled out in the form of a wire as small as $\frac{1}{1000}$ths of an inch in diameter. The sixth and last form described is a carbon filament of the kind lastly described, but coated for the purpose of support with a non-conducting, non-carbonising substance. By his speci-

fication Mr. Edison makes four claims, namely :—"(1) An electric lamp for giving light by incandescence, consisting of a filament of carbon of high resistance, made as described, and secured to metallic wires as set forth. (2) The combination of a carbon filament within a receiver made entirely of glass, through which the leading wires pass, and from which receiver the air is exhausted, for the purposes set forth. (3) A carbon filament or strip coiled in such a manner that only a portion of the surface of such carbon conductor shall radiate light, as set forth. (4) The method herein described of securing the platina contact wires to the carbon filament, and carbonising of the whole in a closed chamber, substantially as set forth." The first claim we understand to be for the entire lamp—that is for all the elements of the invention brought together in one combination. It is conceded by the plaintiffs that the defendants have not used this entire combination, and, consequently, that there is no infringement of the first claim. The second claim is the one in which the real trouble arises, and it is necessary in the first place to ascertain its true construction. To us it has been extremely difficult to follow the learned counsel for the plaintiffs in the interpretation or glosses which they have presented in respect of this claim, because these interpretations and glosses have seemed to us not only to vary but too vague. But in our opinion this claim ought to be construed with all the generality which its words seem to convey, so that it may be paraphrased as a claim to every combination of any carbon filament with any receiver made entirely of glass through which any leading wires pass and from which the air is exhausted. The words "for the purposes set forth" at the end of the claim may govern either the whole claim or qualify the antecedent word "exhausted." In the former case it described the exhaustion of the receiver as introduced for the purpose of preventing alike chemical and mechanical destruction from the presence of any gas —a purpose which Mr. Edison has enunciated and explained in the course of his specification. In this view the second claim differs from the first in not embracing the coiling or other similar arrangement which is the first element of the invention—nor the use of platina as distinguished from other leading wires—nor the mode of attaching the metallic to the carbon conductor. But this second claim embraces a combination of the five elements following, namely, (1) a carbon conductor; (2) in the form of a filament; (3) a receiver wholly of glass; (4) a vacuum; (5) the entrance of the leading wires through a glass receiver: the third claim is for that peculiar arrangement for coiling or similar process by which a portion only of the carbon conductor radiates light, the fourth claim is for the attachment of platina contact wires to the carbon filament and the carbonising of the whole in a closed chamber, so that the third and fourth claims are those very portions of the entire combination which are not in the second claim; or in other words, the entire combination, the subject of the first claim, is subdivided into three subordinate parts or combinations, the subjects of the second, third, and fourth claims. It is satisfactory to find that the wide construction of the second claim was fully present to the minds of the counsel for the defendants when conducting the case in the court below, so that in adopting that construction we are not running any risk of departing from the lines on which the case was fought in the first instance. There was distinct evidence of the utility of the combination contained in the second claim, not so far as was shown us, met by any opposing evidence. Indeed, the utility of the patent, and consequently of everything actually claimed by it, is not in dispute. Furthermore, it is not denied that upon the interpretation we have placed upon claim 2 the defendants have infringed it. The lamp W. and R., which was the subject of admission in the case, appears to us to be clearly an instrument made in accordance with the claim in question—it is a combination of a filament admitted to be carbon with a glass receiver, admitted to embrace a vacuum and with conducting wires passing through the glass. But then it is said by the defendants that the patent is wanting in novelty. It is not indeed contended that the entire combination of claim No. 1 or the subordinate combination of claim No. 4 has been anticipated, but it is urged that the combinations claimed in claims 2 and 3 according to the true reading of them are not novel; that if novel the second claim is expressed with a vagueness which is fatal to its validity and that what was new in that claim is not a good subject of a patent. What then was the state of public knowledge on this subject when the patent of November, 1879, was granted? It was perfectly well known that light was to be produced in an electromotive current by resistance in a conductor. It was further known that resistance depended on four conditions, or factors, namely: 1st, temperature—a matter which as it has not been brought into consideration in this enquiry we may for the future disregard; 2nd, the specific resistance of the matter of which the conductor is formed; 3rd, the length of the conductor; and, 4th, its sectional area. Furthermore, it was shown that from 1845 and downwards various attempts had been made to introduce incandescent electric lamps, but there is no evidence that any such lamp had been made with the exception of two, which had been constructed and exhibited by Mr. Swan. With regard to the lamp said to have been made by Mr. Justice Grove in 1843 no evidence has been given to us. The problem before Mr. Edison was to find some conductor in which he could obtain high resistance to the current with great durability—that is to say, great capacity to resist disintegration by heat and the absence of all disintegrating influences of any gas, whether such influence were chemical or mechanical. The high resistance he might obtain from any use of the three factors already referred to, the specific resistance, or length of the conductor or its sectional area. As we have already seen, Mr. Edison satisfied the conditions of this problem by using carbon, a substance of low conductivity, in a form in which the length of the conductor was great in proportion to its sectional area, and by placing this conductor in a chamber not occupied by an inert gas like nitrogen, but by a vaccum as complete as is obtainable. The importance of this combination can hardly be doubted, for, if not alone, yet in combination with other improvements, it has had this result that, whereas before November, 1879, two or three experimental lamps were all that had been produced, after that date such lamps have been produced by tens of thousands and constitute a most important element in our methods of lighting. In what ways did the alleged anticipations of Mr. Edison attempt to accomplish incandescent lighting? This point we shall first investigate with regard to the second claim. The first specification to which our attention has been called is that of King in 1845. He proposed the use of two kinds of conductors, metallic and carbon. The metallic conductor (for which purpose he proposed platinum) was to be made incandescent in the air. The carbon conductor was to be used in a space from which air and moisture were excluded. "To accomplish this," says the patentee, "in the most perfect manner it should be enclosed in a Torricellian vaccum." So far as Edison uses carbon in the vacuum King was evidently in anticipation of him It becomes necessary, therefore, to consider with some exactitude how King proposed to give effect to this portion of his invention. He explains one form of the apparatus only. This consists of a barometer tube and column, but with the upper portion of the glass tube enlarged so as to contain in it the light-giving apparatus, which consisted of a piece of carbon of the kind found in the interior of coal gas retorts, formed into a small pencil or thin plate, but of a width as shown in the diagram, greatly exceeding that of the conducting wires. The circuit was to be made, beginning at the upper end, by means of, first, a platinum wire sealed through the glass; second, a piece of iron, *d*; third, the forceps attached to the iron and to the carbon; fourth, the carbon; fifth, similar forceps; sixth, a similar piece of iron; and then, seventh, the mercury in the tube, or when this was depressed by the formation of vapour of mercury, a copper wire passing from the lower piece of iron through the mercury column. Now, comparing this apparatus with the combination embodied in the second claim of Mr. Edison, we find a carbon conductor and a vacuum; but we find that the carbon was not required to be a filament—we find that it was to be placed in a receiver made, not entirely of glass, but partly of glass and partly of the top of the mercury column, consequently that the leading wires were to pass, one through the glass and one through the mercury. Roberts comes next with letters patent bearing date 1852. This specification dealt with a wide range of the applications of electricity, and it is only a small part of his specification which at present demands attention. Roberts proposed to obtain electric light by passing a current through a thin piece of graphite, coke, or charcoal, or other infusible body being a conductor of electricity, while it was enclosed in a vacuum not containing any oxygen or other matter which could cause the combustion or destruction of it. The apparatus by which he proposed to effectuate this object consisted—(1) of a glass globe fitted with a metallic cap turned on its outside as a screw; (2) a hollow pedestal furnished at the top with a collar into which the metallic base of the globe screwed; (3) a tube furnished with an appropriate stop-cock passing up the hollow pedestal; (4) a piece of very thin graphite about half-an-inch long, half-an-inch wide, and as thin as might be, suspended in the globe between two metallic rods. The tube passing through the pedestal served two purposes; in the first place it was the means by which an air pump or exhausting syringe was used to free the globe of air, and in the next place it formed part of the line of electric communication, for in this instrument [the current passed from the battery along this tube, then along one of the metallic supporting rods, then along the graphite, then down the other supporting rod which passed through the metallic cap of the glass globe, but was kept from metallic contact with it by ivory or other non-conductor. Now, comparing this apparatus with the second claim of Mr. Edison, we find that it differed in that Mr. Roberts did not use carbon as his sole material, that he was content with the exclusion of gases chemically destructive, and was not alive to the importance of the mechanically destructive action of gases, that his receiver was not made entirely of glass, and that the leading wires did not pass through glass, but through the metallic cap of the receiver. In 1874 or 1875 the Sprengel pump was brought into use, and gave a great stimulus to all investigations into operations carried on in vacuo, and amongst others to electric lighting in vacuo. Mr. Lane Fox's specification of October 9th, 1878 (No. 3,988), is the first that demands attention. This invention consisted in passing an electromotive current through a thin strip or wire of some suitable material—Mr. Fox preferred an alloy of platinum and iridium. In order to prevent the deterioration of the material when incandescent, Mr. Fox states that he sometimes surrounds it with an atmosphere of nitrogen gas. That Mr. Fox's lamp had a great general similarity to the one now in use cannot be doubted; but the most suitable material known to him, and the only one he mentions, is an alloy of platinum and iridium, metals which, though of low conductivity as compared with many other metals, have a high conductivity as compared with carbon. He did not regard inclusion in a glass or any receiver as necessary, and when he did use such a thing he filled it with nitrogen gas. We have not carbon in the filament, not the glass receiver, and not the vacuum of Mr. Edison. In Mr. Fox's next patent, dated October 12th, 1878 (No. 4,043), he

proposed the combination of non-conductors with conducting substances. In the first form he retained his wires or strips of metal (preferably the alloy of platinum and iridium), but he coated them with an earthy non-conducting material, such as lime, because at a given temperature they seemed to radiate or give off more luminous rays in proportion to the non-luminous rays than the platinum-iridium wire at the same temperature. In his second form of conductor he employed asbestos or some other non-conducting refractory material saturated or impregnated with a conducting body, such as carbon or iridium. In whichever of the two ways the conductor was constructed it was to be placed in a glass flask hermetically sealed and filled with nitrogen gas. It is obvious that in the first form of conductor we have a metal and not a carbon conductor; in the second the resistance is raised, not by the reducing the carbon to a filament, but by the intermixture of a non-conducting material with a conducting one, or by the subdivision and extenuation of the conducting material by the mode of its application to the non-conductor. We miss, too, the vacuum which was to protect the conductor from all mechanical deterioration. In short, we have not the carbon filament nor the exhausted receiver of Edison. A few days after the two patents of Mr. Lane-Fox a patent was granted to Mr. Van Choate (October 31st, 1878, No. 4,388), in respect of which he deposited a provisional specification only. The material to be employed by this inventor is vaguely described as "composed or formed of asbestos, mica, platinum, or carbon, or any combination of them, and such other materials as may be required to give the proper affinity and homogeneity to the material." It is evident that this is no adequate description to enable anyone without further experiment to ascertain of what the conductor is to be made, or of what form it is to be. In the following month the industry of Mr. Lane-Fox results in his third patent (November 14th, 1878, No. 4,626). The point here relied upon by the appellants was the description of the conductor contained in the provisional specification. But in our opinion this was nothing other than a repetition of the second form of conductor described in Mr. Fox's specification to his patent of October 12th, and not then filed. There is no new light thrown on the enquiry by this provisional specification. In the same month of November, 1878, letters patent were granted to Mr. Pulvermacher (November 23rd, 1878, No. 4,774). This invention was intended for use in an arc lamp, and though referred to for other purposes, it was not urged upon us that it contained any anticipation of the combination contained in the second claim. Next comes Mr. Lane-Fox's provisional specification of March 20th, 1879, (No. 1,122) which proposed to construct the incandescent portion of a conductor by a mixture or combination of two highly refractory materials, one being a conductor such, for example, as plumbago, and the other of non-conducting or badly conducting material, such as magnesia, terconia lime, steatite, or earthy matter, and he directed that the non-conducting material should be considerably in excess of the conducting material. The conductor was to be enclosed in a globe from which not all gas, but, as we read the specification, any gas or matter capable of effecting a chemical change in the luminous bridge, should be removed. It is evident that here we have neither the carbon conductor for the filamentous form, nor the vacuum of Mr. Edison. There is no evidence that a single lamp made under any one of the specifications or provisional specifications we have referred to ever gave a ray of light. The rapidity with which the patents succeeded one another in 1878 and 1879 shows how keen was the race for the production of a good incandescent electric light, and the fact that no one of the inventors in question is shown ever to have succeeded seems to be strong evidence that every one of the ingenious apparatus which they devised resulted in failures. On the 19th December, 1878, Mr. Swan, one of the present plaintiffs, exhibited to the Newcastle-upon-Tyne Chemical Society a lamp constructed entirely of glass, containing in vacuo platina leading wires hermetically sealed into a glass, between which wires was suspended a rod or pencil of carbon, slender, but not so slender as to be described as a filament. This produced incandescent light for a while, and then the carbon rod bent or bulged downward in consequence, as it appears, of the electromotive force being too great for the cylinder of carbon, and the inner side of the glass was lined with a sooty deposit which, on examination, proved to consist of platinum, carbon and iron. On the 3rd February, 1879, Mr. Swan, in the course of a lecture to the Literary and Philosophical Society of Newcastle, exhibited a second lamp of the same construction which gave out a very considerable incandescent light for some 20 minutes. It has been on exhibit in this cause, and appears, like the first lamp, to have become to some extent coated on the inner surface with a dark deposit. On the 2nd March, 1879, Mr. Swan again described his lamp to a Gateshead audience, but it does not appear that he exhibited it, and from that time it has, so far as this case is concerned, disappeared from history, and this disappearance is, we think, cogent evidence that Swan's lamp as it was exhibited was not a practical success, that Swan could not do what Edison did, and that the difference between a carbon rod and and a carbon filament was the difference between failure and success. The result of this review of all the alleged anticipations of the second claim is to convince us that there was no case in which there were brought together all the five elements which we have pointed out as combined in Mr. Edison's second claim—carbon in a filamentous form in a vacuo, and in a receiver entirely of glass through which the leading wires pass. But as between Swan and Edison the difference is only between a rod and a filament, that is a difference of degree and of degree only. Mr. Edison has in his specification given no definition of a filament, and he has nowhere drawn the line between it and a rod. The specification is therefore itself argued bad as being too indefinite and vague. To this argument it may, in our opinion, be properly replied, that in a patent of this description definition is required only to such an extent as would enable a practical workman to construct the required apparatus, that there is distinct evidence that such a workman could make the required apparatus from the specification, that no witness of the defendants alleges that such a workman would have any difficulty, or would require any further experiments, and that the specification itself, as we have already shown, contains descriptions of six forms of filament, and those descriptions, it is obvious, would afford material assistance to any workman in doubt. It is urged that a mere variation in the size of a part of the lamp is not the subject of a patent. It may well be that no patent could be sustained for the use of a filament of carbon alone; but when that filament is part of a combination which is useful, and replaces a rod in an earlier apparatus which was useless, we can see no reason why the new useful combination may not be the good subject of a patent. It was strongly argued that the mere change of the size of a part of the combination cannot constitute a new manufacture so as to be the subject of a patent. In most instances this may be true, but the present case is peculiar. Two, and, so far as we have learned, only two, specimens of the earlier form of the instrument have been constructed, and in both of those a rod and not a filament of carbon had been adopted. Mr. Edison used the filament instead of the rod for a definite purpose, and by the diminution of the sectional area made a physical law subserve the end he had in view. The smallness of size, therefore, was no casual matter, but was intended to bring about, and did bring about, a result which the rod could never produce, and so converted failure into success. The point upon which Mr. Edison's instrument departed from Mr. Swan's was crucial, and the departure, though slight, had all the merits of a new invention, and produced a new apparatus. Three cases were cited to show us that a mere variation in the size of the carbon conductor will not constitute the good subject of a patent. The first was Kay *v.* Marshall, where the improvement claimed consisted in placing two rollers nearer to each other than they were previously used; but, in practice, before the patent, the distance between these rollers had been varied according to the fibre of the substance to be spun. The invention, therefore, was for the use of a well-known machine in a manner in which it could have been previously used. To grant letters patent for such an invention would have deprived the public of the means of using a machine which they had previously enjoyed. In Ralston *v.* Smith (11 House of Lords cases, 223), the patentee claimed to have invented improvements in embossing and finishing woven fabrics, and in the machinery employed therein, and the House of Lords held in substance that all that was described in the specification was a new use of an old machine, and that this was not a new manufacture within the statute. In Patterson *v.* the Gas Light Company, Limited (2 Chancery Division 812), the Court of Appeal held that the invention claimed was only an invention for the more beneficial working of an old process, and that this was not a new manufacture. It does not appear to us that any of these decisions show, or tend to show, that the introduction into an old combination of a new shape of one of the old elements of that combination which invokes a law of nature, otherwise left on one side, may not be the good subject of a patent. For these reasons we are of opinion that the objection to the second claim fails. With regard to the third claim, which relates to the peculiar arrangement adopted by Mr. Edison by which he reduced the light-giving surface of the carbon in proportion to its length, it was contended that this was anticipated by the publication of the specification of Van Choate and Pulvermacher. Van Choate, it will be remembered, proposed to employ a substance composed or formed of asbestos, mica, platinum, or carbon, or any combination of them, and such other material as might be required to give the proper affinity and homogeneousness to the material. This substance, he further says, was preferably made into wire or ribbon, and formed into arcs, spirals, or spiral globe-shaped illuminators or burners, or the material might be formed into discs or globes, or spirals wound round a central wire or body, or into other shapes required to form a light. It is obvious that the purposes for which Edison uses a coil, namely, the diminution of the radiating surface and the raising of the specific heat of the whole, were not only absent from the mind of Van Choate, but would not result from large spirals which are manifestly within his provisional specification. In Pulvermacher's invention a spiral or screw-shaped rod was used, but this was for the purpose of illumination, not by incandescence, but by the voltaic arc, and consequently it had no real relation to the coil of Mr. Edison's lamp. For these reasons we are of opinion that the third claim was not anticipated. In the result the appeal in our judgment fails.

LORD JUSTICE COTTON: I am unable to agree with that, which is the judgment of Lord Justice Bowen and Lord Justice Fry; and I differ from them principally on the question of the construction of this specification. Of course, differing from them as I do as regards the construction of this specification, I should say that if I agreed with them I should differ from them, as I shall hereafter point out, as to the effect of Swan's lamp. The question turns on claims 2 and 3 really, because those are the points on which it is said there has been an anticipation. As regards claim 3, I put that aside, because I agree with Lord Justice Bowen and Lord Justice Fry that Van Choate's is no anticipation of the spiral described in this specification. But the question then comes as to the second claim, and I shall confine myself to that, but for this, that the construction put by the other Lords Justices on the

first claim in my opinion has an effect, and an erroneous effect, on the true construction of claim No. 2. The only question arises as regards the second claim; but then to construe that properly we must see what was the proper construction of the previous patent. Lord Justice Fry has said that in the opinion of himself and Lord Justice Bowen that is a description of the whole combination which is described in the previous part of the specification. In my opinion that is erroneous; I cannot agree with that. What are the words of it? "I claim as my invention an electric lamp for giving light by incandescence, consisting of a filament of carbon of high resistance made as described, and secured to metallic wires as set forth." Now, that entirely omits the globe, which was to be a vacuum, and in my opinion is confined to that which he has previously said is part of the invention, and the material part of it, that is to say, constructing a filament of high resistance as described and securing that to metallic wires as set forth. In my opinion, although if this were well-drafted it would be proper as a matter of good-drafting to put the whole combination either first or last, yet there is in that first claim simply a claim to the incandescent portion of the lamp. He calls it lamp, but he means the incandescent portion of it, consisting of a filament made as described and secured as described to metallic wires. There is nothing about a vacuum, and nothing about the glass globe in which this was to be. I may mention that when he describes how it is to be made, he first of all connects his filament with the wires, and then he puts that, after it is so constructed into the globe, from which he exhausts the air. I mention my difference from them on that point because I think that rather leads them to the view which they take of this second claim. If the whole combination had been claimed beforehand you might expect the second to be something different; but the second is clearly and simply a claim to a combination. What is it? A combination of a carbon filament within a receiver made entirely of glass, through which the leading wires pass, and from which receiver the air is exhausted for the purposes set forth. Now, my only difference from them is as regards what there is meant by a carbon filament. Their view is that that means anything which can be called a carbon filament. Now, I differ from that. What is the general purpose and object of a claim? Its general purpose and object is that the patentee may show how much of that which he has described in his specification he claims as protected by his patent. It must be construed in my opinion with reference to that which he has already stated in his specification when he is defining the invention for which he has taken out a patent, and how the invention may be carried into effect. As a general rule the object is to say, "Notwithstanding what I have described, all that I claim is" so and so, and to limit, therefore, his claim to a certain portion of that which he has previously referred to in describing his invention. It may be, and frequently is, that where a patentee has described in his specification a certain particular mode of carrying into effect his invention—as in this case in what he says about filaments—he there says:—"Now mind, although I have only mentioned beforehand certain specific forms of that which I call a filament, yet I claim everything which can be called a filament, and the combination of that with the other portions which I have described before." But here that has not been done. It is only the combination of a carbon filament. Would it be right, if we are to construe this fairly, to say without reference to what the consequence may be, that he here claims the combination of anything which may be called a carbon filament with the other portions of his lamp. We must remember that at this time filament as applied to electric lamps was not a well-defined or known term. It is used, I agree, especially in the account we have had of Sidot's process; the word was used and it was not a new word. It was certainly used in botany, and although it was stated by the Attorney-General that this was a word of art employed at the time when this specification was filed, there was no evidence to show that it was. There is the difficulty in this case, as there must be in all cases where strides are made in the knowledge with reference to a particular matter, in separating knowledge at the time of the specification from the knowledge which exists in the minds of the witnesses and others at the time when the matter comes before the court. The only way really of testing it is looking at the knowledge at the time of the invention; and there what we find is this, that this filament—that is my opinion—was not a word which had been defined in its application with reference to this matter at the time of the invention. When we come to one of the witnesses, Dr. Hopkinson tells us that it is a question of degree to decide where filament begins and where it ends. If this is to be in everything which is a filament, everything which is long and with the sectional area very small, then, in my opinion, there would be a great many difficulties as regards the validity of this patent. In the first place, if that was so, and filament only depends on a question of degree, not to be fixed as commencing and ending at any particular point, I cannot see how Swan's lamp was not an anticipation. There was a lamp with the exhausted receiver and a piece of carbon connecting the two wires which brought and took away the electric current, which made it part of the circuit, and thereby its greater resistance produced the light; it was of small sectional area, though certainly not such a sectional area as was used by either the plaintiffs or the defendants. But here, if this is to be applied to every filament, there being no particular mode of combination pointed out, as I put it to Mr. Aston during the argument, "Would you say that if this combination is used it matters not whether the filament is straight or whether it is curved, or whether it is wound into a spiral?" He answered, "Yes, I think it would." That being so, to my mind, if the construction, having regard to the indefinite use of the word filament (I am using it with reference to it being a mere matter of degree), then I should say that Swan's, which was not a mere unsuccessful experiment, but which produced a lamp which burnt without intermission and with good effect—the second lamp, I mean, because the first was spoiled in consequence of the current of electricity being too large—I should say, taking the construction which was put upon these words by the other Lords Justices, that would be an anticipation of Edison's second claim. But that would not be the only difficulty. If that were the necessary construction of that, it is unnecessary to give a definite opinion upon it, because, in my opinion, it is not the true construction. I should have great difficulty in dealing with the objection to this patent that it is so vague and indefinite as to be bad; and I will mention here that I am not impressed as the other Lords Justices seem to be by the evidence of the witnesses that no competent workman would have a difficulty in carrying into effect Edison's invention. What they are referring to is the description given in the previous part of the specification, where he does disclose a mode of carrying into effect his invention, and no doubt the evidence is, having regard to that, and looking to those filaments there described, that no workman would have difficulty in carrying it into effect; but they do not say that if this were to be applied to every filament then the workman would have known what was meant by the word filament—would have known at, or shortly after, the time of this specification—or that he would be free from difficulty, and be able to carry it into effect without experiment. Really the questions are different. Then what is the claim? What is the invention for which protection is claimed? With reference to that we must not look to see how far a workman would have any difficulty in working a previous description, but whether that claim is confined to that which is previously described, or whether it launches out into a variety of other pieces of carbon which are not therein referred to, and in my opinion, construing as I think one ought to do the second claim with reference to the previous specification, and not applying it to everything which can be called a carbon filament, I think one ought to refer it back to that which has been referred to in the previous part of his specification as a filament, and one finds that in the beginning he speaks of carbon wires or sheets. "The invention consists in a light-giving body of carbon wire or sheets." And then he goes on with the coiling. On page 4 he refers to a filament as sometimes a wire and sometimes a thread, and in my opinion the proper and true construction of this second claim is a combination of a carbon filament, in substance such as is herein before mentioned, with the other matters which he refers to in his combination. The whole of that second claim is very badly drafted, because it is the combination of a carbon filament within a receiver made entirely of glass—that is, the combination of a carbon filament with nothing, only in a receiver, but I take it the true construction, construing it fairly, is that it is the combination of a carbon filament with a receiver made entirely of glass. Then I come to the question, What is the result? And, in my opinion, the construction that I put on this specification establishes the validity of the patent; that is to say, prevents it from being held invalid either from vagueness or anticipation. But what is the result? Has there really been any infringement? There is a carbon filament undoubtedly in the lamp of the defendants. But now what is the essential part of a carbon filament as herein before mentioned in the specification? In my opinion—and it was hardly contested—it was not confined to a carbon filament used exactly as described, and the judge held that there was no evidence that that had been done. The words are, "as described;" the description is of a particular way or particular ways of making carbon filaments, and really in the specification the greatest stress is laid on the coil or the spiral, so as to have a long filament of very minute sectional area. But what Mr. Aston said was this, that a filament necessarily implied flexibility and resilience. Now I cannot find that at all in the specification, and of course we must look to the specification in order to see whether the filament, such as is mentioned, necessarily involves that flexibility and resilience. Flexibility, in my opinion, is contrary to the specification. There must be flexibility before it is carbonised; but we have to deal with the carbon filament after it is carbonised. There is nothing in the specification which requires the flexibility, or, as far as I can see, the resilience. But the Attorney-General, although contending for a more general sense of carbon filament in the second claim, said that it is every filament, subject to this restriction or qualification—if he put any—that it must be made into a filament before it is carbonised. At first I thought that there was nothing in the specification which would lead to that conclusion, but on looking carefully at it, it appears to me highly probable that the essential part of what he described in this specification as filament was, that it should be made into a filament, that is to say into a fine wire or thread, or exist as a fine wire or thread, before it was carbonised, and there are a great many passages in the specification, which is the only thing one would look to to rely on in a matter of construction, which will lead to that conclusion, because I find this on page 4. He describes how to make a very fine wire out of some plastic material, and then he shows how that is to be formed into a spiral. Then he says on line 8: "The spiral after carbonisation retains its form." Then he says what may be done to prevent the bit of wire which he has wound cracking during the process of carbonisation. It cannot be afterwards, because he says: "I sometimes roll a thread within the compound of lamp-black and tar so as to allow of greater convenience in handling the same." That must be before it is carbonised. "The flexible carbon filament is not so liable to crack by its own weight in the act

of winding." It is not to be wound after the carbonisation, that is perfectly clear. Then on the same page, line 40: "Also lampblack, plumbago and carbon in various forms, mixed with tar, and kneaded so that the same may be rolled out into wires of various lengths and diameters; each wire, however, is to be uniform in size throughout. "If the carbon thread is liable to be distorted during carbonisation it is to be coiled between a helix of copper wires." Then he explains how the copper wire is to be eaten away after carbonisation. Then on line 51 he says: "With substances which are not greatly distorted in carbonising they may be coated with a non-conducting, non-carbonising substance, which allows one coil or turn of the carbon to rest upon and be supported by the other." There are other passages in the specification which show clearly that what was contemplated always was making a filament, and in these cases rolling it before carbonisation, and one finds this, that Sir Frederick Bramwell, who was the leading witness on the part of the plaintiffs, does recognise the importance of making the filament before carbonising it, and relies on what he thinks exists here, the filament existing before it was carbonised. I will not read his evidence again, in this case, but on page 19, in answer to questions in the early part of his evidence, we find this: "Do you find in the specification that the filament is to be formed before or after carbonisation?—A. Before carbonisation." And then, I think in the re-examination, he sums up in these terms, in answer to questions of counsel and the judge as to what he thinks of great importance. "Mr. Aston: In not one of the prior specifications was there any other method of dealing with carbon intended to be used in any incandescent lamp other than shaping the carbon previously made and giving it the form it was intended to give it? That is to say, previously the burners, or whatever you like to call them, were carbon, and then you cut them into the form required by the person who was making the lamp. Mr. Justice Butt: There is nothing beyond shaping the carbon previously made?—A. Where carbon alone is used, I believe that is so. Where sticks and pencils and things of that kind are used, I think you will find they are made out of that which was carbon before they were manufactured. Mr. Aston: So that shaping was by means of a saw and file?—A. A saw and file. Q. Edison does not make his filament in that way?—A. No, he does not. Q. He makes it in various ways, forming the filament first and then carbonising it afterwards?—Mr. Justice Butt: That is really quite clear on the evidence in chief, that he makes it of any fibrous material, and then turns it into carbon instead of taking carbon and sawing and filing it down." So that there, Sir Frederick Bramwell, in the beginning and in the end of his evidence, the judge then holding that that was the result of all the evidence, points out specifically that in his opinion that was essential as regards what was called the filament or thread here—that there should be a filament formed, and that that filament should be afterwards carbonised. That being so, if the other Lords Justices agreed with me in the construction to be put upon this specification, I think the proper course would be to ascertain by one of the ways offered on behalf of the defendants here, but so as not to divulge that which is their trade secret, how it is that the filaments, if they are to be so-called, which are used by them are in fact made. It was said by Mr. Aston, and in fact it was admitted in the course of the argument, and was that which the whole argument and the evidence proceeded upon, that the filament of the defendant was made into that shape before it was carbonised; and there was a passage which no doubt very much supported that view, because at the end of Mr. Rawson's evidence there was a passage which was much relied on by Mr. Aston as showing that that was so. It is at the end of his cross-examination. "Never mind what Edison has used. Your answer is quite sufficient. A deposit of carbon which is caused to be deposited so as to secure your filament to the platinum wire is a deposit of carbon put there after the filament is formed?—A. Yes."

Mr. ASTON: Yes; that is to form the terminals.

LORD JUSTICE COTTON: Oh, yes. I quite understand that. I was going to explain that. The carbon filaments are joined by the defendants in a particular way, not that of Edison, to the wire, and that is what Mr. Aston is speaking of. "Mr. Justice Butt: What is that answer? Mr. Aston: A deposit of carbon which Mr. Rawson says he employs to effect the junction of his filament and platinum wires is put there after his carbon filament is formed.—A. And carbonised. Mr. Justice Butt: The carbon he says is placed there after the filament is formed and carbonised?—The Witness: That is, by carbonising I mean what is usually commercially spoken of as carbonising. It is different in our case, but it is called carbonising." There he is referring to the state of the filament before the junction is effected between the platinum wires and the filament, and if that is not carefully looked to it might be considered that he was saying the filament was first formed and then carbonised; but no, he says before the junction is effected the filament is a carbonised filament, and then only, and not after that has been performed is the junction effected with the platinum wires. In my opinion if, as relied upon by Sir Frederick Bramwell, and as relied upon by the Attorney-General, the forming of the filament before it is carbonised is the essence which runs through all the filaments mentioned in the specification, the question ought to have been put pointedly in cross-examination by the plaintiffs' counsel to Mr. Rawson: "I do not now ask about the time when you apply that which is to form the junction between the platinum wire and the filament. I do not ask about when that was done, but when do you carbonise the filament? Is it after the filament is made into a filament, or do you do it at the same time in some other way?" So that, I say if the case rested on my opinion, I should desire to have that further evidence before I should say in this case that, although the patent is good, there has been infringement. But as the other Lords Justices agree in a different construction, which would of course have a different effect on the evidence, the appeal here must be dismissed.

Mr. ASTON: And dismissed with the usual consequences, my lord?

LORD JUSTICE COTTON: Yes.

Mr. ASTON: There is an arrangement made between Sir Horace Davey and myself, or the Attorney-General, that under certain terms the defendants may continue the manufacture of their incandescent lamps.

LORD JUSTICE COTTON: Do you mean continue generally, or pending the appeal?

SIR HORACE DAVEY: Pending the appeal, and it extended to both patents.

Mr. ASTON: It did, and I propose that that should continue until the decision in the second patent is given. May I respectfully ask when that may be expected, my lord?

LORD JUSTICE COTTON: I hardly like to say. I expected we should have given it by this time, but I have not had an opportunity of consulting with the other judges.

SIR HORACE DAVEY: Your lordship will anticipate that the parties may desire—I don't say more than that—to go to the House of Lords upon this patent. In that case I shall probably be instructed to ask your lordships to suspend the injunction on certain terms.

LORD JUSTICE COTTON: It now stands suspended until the other judgment is given.

SIR HORACE DAVEY: Yes, my lord, but the arrangement between my learned friend and myself extends to both patents. My learned friends think that the more convenient course is that that should be continued. That is that the injunction be suspended until after the judgment is given in the Cheesbrough case.

Mr. ASTON: On the same terms.

LORD JUSTICE COTTON: We hope that will not be long delayed, but that is all we can say now.

SIR HORACE DAVEY: Your lordships probably will not object.

LORD JUSTICE COTTON: Settle the terms between yourselves.

NOTES.

Electric Lighting at Cockermouth.—The Cockermouth Local Board is promoting a Bill to enable it to undertake electric lighting and gas works. The Bill will be first brought in in the House of Lords.

The Electric Lighting Act.—Mr. Hugh Watt, Chairman of the Maxim-Weston Electric Company, introduced a Bill to amend the Electric Lighting Act of 1882 in the House of Commons on Friday, and it was read a first time.

Electric Lighting and Tramway Work.—The old fortress of Temesvar, in the south of Hungary, was one of the first towns that adopted the electric light. An installation of incandescent street lighting was started on the 30th November, 1884, with 731 Lane-Fox lamps, worked by Brush dynamos of 1,500 volts pressure. Some of the lamps are, *Industries* states, still in use, having lasted for 6,500 hours, and it is satisfactory to note that, notwithstanding the high pressure employed, there was, during the whole time, not a single accident, nor any serious breakdown. Encouraged by this success, the Corporation of Temesvar are now considering a further application of electricity, for the purpose of working their tramways by electric motors. The project is to run street cars, fitted with accumulators, which would be charged at the electric light station during the day, and in this way the generating plant would be kept more fully employed, and thus made to yield an additional profit.

New Lighting Scheme for Chicago.—Professor Barrett, the city electrician of Chicago, under whose guidance the elaborate system of underground conduits for telegraph wires was developed, has proposed an ambitious plan, the New York *Electrical Review* states, for lighting the entire city with electricity, claiming that it can be done much more brilliantly and at less expense than by the use of gas. The city contemplates trying the system this year to the extent of placing electric lamps along the banks of the Chicago river and at the approaches to the bridges.

Electric Lighting at the Indian and Colonial Exhibition.—In an article dealing with the report of the Electric Lighting Committee of the recent exhibition, the *Engineer* says :—"The total number of lamps used was 413, and $\frac{220,410}{413}$ = 533 watts per lamp, or about $\frac{5}{7}$ horse-power. This is consistent with the idea that the electrical output was measured at the lamps. If it was measured at the terminals of the machines, then very little electrical energy could have been lost in the lamps, but the efficiency of the machines must have been very low. Even allowing 1 horse-power per lamp, instead of $\frac{5}{7}$, we find that 1,000 indicated horse-power produced only 413 electrical horse-power. This is, to say the least, a fact worth having, and seems to prove that electricians do not know everything yet. We hear of machines with an efficiency of 90 per cent. It would appear that none of these found their way to the Indian and Colonial Exhibition, for after every allowance is made for the difference between the indicated horse-power and the effective horse-power of the engines, 413 seems a small return out of 1,000. . . . . Leaving the incandescent lighting on one side, we have for the interior £14,523 by about 600 hours, we have an expenditure of £24 per hour ; or for each lamp, very nearly 1s. 2d. per hour. It must be remembered that this does not include in any way the value of the plant or the sums paid in salaries. It is only fair to electric lighting to say that we have no doubt arc lighting can be done for less than half this expense." The table given showing the efficiency of the accumulators used, our contemporary says, is not quite so intelligible as it might be.

A New Electric Lighting Company.—The prospectus is issued of the St. James's Electric Light Company, with a capital of £50,000 in 10,000 shares of £5 each. The object of the company is to supply electric light and power to the local authorities and to the principal clubs, theatres, public and other buildings in or near the parish of St. James's, Westminster, and to undertake the wiring and equipment of the buildings in which the electric light may be adopted, and to supply all machinery, lamps, materials, and appliances in connection with electric light and power. A contract, the prospectus states, has been entered into by which the contractors undertake to acquire a site for the benefit of the company, to erect thereon a suitable building and to supply and fix therein all necessary machinery sufficient to supply 5,000 lights, and to lay the necessary circuit by overhead wires, so as to comprise all the principal buildings in the parish of St. James's, for £45,000.

Edison Lighting Systems in America.—The Edison Illuminating Company, Boston, Mass., has commenced paying monthly dividends of 1 per cent. The Boston station shows, it is said, the best profit out of 68 Edison stations in this country. It was constructed by the Jarvis Engineering Company, of Boston, and speaks well for the system of using high-speed engines and burning screenings for fuel under boilers set with the Jarvis boiler setting.

Electric Lighting in Belgium.—The new military hospital at Etterbeek, *Industries* states, is to be supplied with the electric light, at an estimated cost of £1,500. The installation consists, in the courts and lobbies, of 58 lamps of 16 to 20 C.P., supplied by a compound dynamo of 65 ampères and 65 volts, while the interior of the buildings will be lighted by 155 lamps of 16 C.P. and 320 half power lamps, supplied by a dynamo of 300 ampères and 65 volts.—The commune of Berghem, near Antwerp, has adopted the electric light, which will also be used at the railway station.—The National Bank at Brussels is also to be lighted by electricity, incandescent lamps being employed in the offices, and arc lamps in the courts and lobbies.

Electric Search Lights.—The *Engineer* of last week contained an article upon this subject, in which was sketched the history of search lights and their uses.

The Electric Lighting Act.—In the House of Lords on Monday, Lord Thurlow presented a Bill to amend the Electric Lighting Act of 1882, and it was read a first time.

Telephone Extension in Scotland.—The National Telephone Company opened an exchange at Dunfermline on the 31st January, starting with 14 subscribers. At present the wires do not extend beyond the limits of the burgh, but the trunk line which is to connect Dunfermline with Alloa, Stirling, Falkirk, Glasgow and Edinburgh has been commenced. The work has been done under the direction of Mr. James Townsend, the company's district manager for the south central division of Scotland.

Lectures on the Telephone. — At Maryport, on January 23rd, a large audience assembled at the Scientific Institution to hear a lecture delivered by Mr. F. F. Bennett, the National Telephone Company's district manager in West Cumberland, the subject being the "Telephone and its applications." Many interesting experiments were performed ; and the proceedings were terminated by a telephonic concert, probably unique in its way. Wires were brought into the hall from the Maryport switch-room and connected to a number of telephones distributed amongst the audience. Miss Richardson, at Cleator Moor (17 miles distant), sang several songs, which were accompanied on the piano by Miss Burnett, at Workington (6 miles). Mr. J. W. Brown, at Paton (12 miles), gained much applause by a cornet solo ; while Miss Hume, at Whitehaven (14 miles), and Miss Stansfield, at Curzon Street, Maryport (half mile), contributed pianoforte solos. Votes of thanks to the lecturer and the far-away performers were carried by acclamation.

Destruction of Telephonic Plant. — Under this heading we reported in our last number that the damage caused to the Genoa telephone net was more than £80,000, which figure should be taken for lires (francs), not for pounds sterling. We have since been informed that the loss is not so serious as estimated at the moment of the first emotion, and that the Societá Telefonica Ligure will continue its operations. Arrangements are already made to begin the re-construction with all possible despatch, and steps will be taken to render the net safe from future snowstorms, although these are of very rare occurrence in Genoa. The disaster was caused principally by the inability of the company to secure permission from proprietors to make proper attachments.

The Telephone between Brussels and Paris.—The recent trials upon the new telephonic circuit established between Brussels and Paris, have given most conclusive results. Not only is it now proved that by employing bronze instead of iron for a telephonic circuit, speech is transmitted more easily from Brussels to Paris than between two subscribers in a single town, but the more important fact is brought to light that one can telephone with this degree of perfection whilst the telegraph is being worked upon the circuit used for the telephone. It is thus demonstrated that if, by degrees according to requirement, the iron wire at present used on telegraphic lines is replaced by copper or bronze wire, and if the Van Rysselberghe system is adopted, as is the case upon the whole of the Belgian network, one will be able to establish, between Brussels and Paris, as many telephonic circuits as there are telegraphic wires.—*La Nation.*

The correspondent of the *Daily Chronicle* at Paris, telegraphing on Sunday night, said :—"Although the

telephone between Brussels and Paris was successfully inaugurated yesterday, it will not be open to the public until February 15th. Other lines will afterwards be available for Lille and Havre. It is probable that the Ministry of Posts and Telegraphs and the telephone company will soon come to an understanding for the extension of the privilege to their subscribers."

Telephony in Austria.—The Austrian Government has decided to do some telephone work. Having connected Vienna and Brünn on the Van Ryselberghe system, the intention is now to open exchanges in such towns where no concessions are granted, and a beginning will be made with a few towns near Vienna, viz., Weiner-Neustadt, Voslan, Baden, and Richenan; perhaps Salzburg may be added. How far this will prove a good move remains to be seen. In a country where the Government machinery is very cumbrous, with an army of officials, officialism is sure to pervade all, and that is the great drawback in telephone business where the general public expects every consideration, the telephone being not yet a necessity like the telegraph. The experience of the Spanish Government will probably be also that of the Austrian.

Royal Users of the Telephone.—The Queen of the Belgians heard by telephone a few nights ago in her palace at Brussels an entire act of *Faust*, then being performed at the Paris Opera; and on Wednesday the King had a conversation with M. Grévy at the Elysée.

The Valve Telephone.—We would like to ask the New Telephone Company whether there is any truth in the report that the valve balls in Prof. S. P. Thompson's instruments are now made in carbon instead of, as formerly, with a metallic alloy.

Prof. Bell's Library Burnt.—A fire broke out in the early part of last month in the upper story of the house owned by Alexander Graham Bell in Washington, and caused a loss of $50,000. The origin of the fire is unknown, but it is supposed that it began in the laboratory, which was located in the attic story, and which contained a number of Prof. Bell's electrical appliances. The library, containing about 5,000 volumes, principally of a scientific character, was almost totally destroyed. The insurance is supposed to be about $25,000.

The Society of Telegraph-Engineers and Electricians.—The next meeting will be held at 25, Great George Street, Westminster, S.W., on Thursday, February 10th, when the adjourned discussion on Prof. Silvanus Thompson's paper on "Telephonic investigations," will be taken.

Incandescent Lamp Patent Litigation.—We believe it is almost certain that Messrs. Woodhouse and Rawson will appeal to the House of Lords from the decision of Mr. Justice Butt, which has now been supported by the Court of Appeal.

Underground Telegraph Wires.—In view of the wholesale destruction of telegraph wires during the recent storms, the question of laying them underground has been under the consideration of the authorities. At Yeovil the Local Board has granted the necessary permission for laying pipes from the post-office to the railway station, so that an experiment may be made with underground wires. The route will be decided after consultation between the surveyor of the local authority and the engineer of the post office.

Fire in a Telegraph Office.—Shortly after 7 o'clock last Saturday night a fire broke out at No. 24, Royal Exchange, Threadneedle Street, in the occupation of the Compagnie Francaise Telegraphe de Paris à New York; the flames originated in the basement, where a large quantity of "telegraph tape" was stored. The fire was confined to the basement, though not before a considerable amount of damage had been done alike to the premises and contents.

Atlantic Telegraphs.—We understand that Mr. Weaver, the managing director of the Anglo-American Telegraph Company, is at the Hotel d'Athenée, Paris. It requires no excessive stretch of imagination to connect this visit with the late secession of the Pouyer-Quertier Cable Company from the pool arrangement for trans-Atlantic traffic.

Underground Telegraphs in Germany.—The *Times* correspondent at Berlin states that he recently received the following communication from the Ministry of Posts and Telegraphs:—"Your recent telegram to the *Times* on underground telegraphs may have been liable to misconstruction on two points, namely:—(1) You said that 'the great bulk of correspondence in Germany is still forwarded over pole-supported wire.' This assertion might lead to the idea that the subterranean cables are but a make-shift, and only intended to serve as a kind of reserve in case the over-head lines fail. But nothing would be more erroneous; for by the trunk lines of the underground cables connecting our principal places and chief commercial cities of the Empire there is forwarded the whole traffic of those places, which amounts nearly to one half of the whole telegraphic traffic of Germany, and includes considerably more important correspondence than is generally exchanged between places of lesser note. (2) It seems that in the telegram alluded to, too much stress was laid on the military necessities of the Empire, which are said to have caused, 'probably as much as anything,' the construction of a telegraph cable net. From a memorandum laid before the German Diet in 1876, it appears that the Postmaster-General, Herr von Stephan, immediately after being asked to assume the duties of chief telegraph officer of the Empire, carried out his well-considered plan of underground telegraphy with the sole object of putting the ordinary and every-day interests of the nation beyond the chances of bad weather. After the realisation of this idea the underground cables were speedily recognised to be an excellent means of keeping up telegraphic intercourse in case of war from the very extended frontiers of the East to the passes of the Vosges, and only then were they made subservient to our military necessities."

Fatal Accident to a Lineman.—A telegraph lineman, named Thomas Fagan, whilst engaged in repairing the telegraph lines at West Drayton, on Tuesday, was knocked down and killed by the hunting special train from Slough. The deceased, said to be a married man, belonged to Oswestry.

Underground Cables in New York.—The Consolidated Telegraph and Electric Subway Company has made contracts to have over 800 miles of conduits laid in New York early in the spring. The first conduit was started last August, two miles being laid, consisting of 24 ducts, 2½ inches inside diameter, on the Dorsett system. Each duct might contain 200 wires, according to the gauge. This spring it is expected to expend £500,000 in putting wires underground in New York City, using, in all probability, a variety of systems. At the present time there are 10,000 telephones in use in New York City alone, and these, with the telegraph and district messenger service, and other electric services, involve the use of about 25,000 miles of wire. It is estimated that there are now 100,000 poles in use, which number will probably be reduced to one-half this year.

The First Anglo-French Cable.—We are obliged to leave over this week, in consequence of its late arrival, an article on the first submarine cable between France and England. It will prove of considerable interest to our readers, it being suggested to the writer by a perusal of Jeans's recently published "Lives of the Electricians"—which was reviewed at length in our columns—and the inaugural address of Sir Chas. Bright to the telegraph engineers and electricians.

Fire Alarm Cables.—A new contract for fire alarm cables, *Industries* states, has been commenced in New York, requiring 200,000 feet. It is being constructed on the Waring system, and is expected to be completed in 30 days; the same system is at present being laid for the Western Union Telegraph Company, who require not only a cable that fills the requirements as to insulation and conductivity for their high tension currents, but one which will also withstand the heat from neighbouring steam pipes, which supply heat to business houses and dwellings. After many tests, the Waring cables were selected as meeting these requirements. They are all lead covered, and contain a number of insulated wires.

Sale at Colonial and Indian Exhibition.—The electric lighting plant, which has formed one of the prominent features of the annual exhibitions at South Kensington, was brought to the hammer on Wednesday and Thursday last week by Messrs. Wheatley Kirk, Price and Goulty. It is believed that such a group of modern high-class motive power producers has never before been offered for sale, and, as the occasion deserved, there was a large attendance of buyers, and good prices were obtained for most of the lots. The average price at which the boilers were sold was about £180. The largest of the Davey-Paxman engines (horizontal high pressure, coupled, 300 indicated horse-power) brought £490, and another (Colchester horizontal high pressure compound fixed, 200 indicated horse-power) £390. Messrs. Galloway and Sons' pair of compound horizontal non-condensing twin engines, which were specially made for the fountain lighting last year, were bought in at £680, but the Goodfellow and Matthews triplex tandem engines, employed in the same duty the year before, did not find purchasers. An Elwell-Parker 40-unit 4-pole dynamo, shunt wound, sold for £240, and a 12-unit machine by the same makers for £85. The incandescent lamps, which had been some time in use, sold very well, the prices ranging from 1s. to 2s. 7d. each, and cable which had been in use more than one season averaged £45 a ton. Among the buyers were the Marquis of Salisbury, the Marquis of Bute, the Duke of Marlborough, and Lord E. Churchill, the Marquis of Bute obtaining some of the best of the boilers and engines.

The Testing of Dynamos and Motors.—The first of the seven demonstrations to be given by Professor W. E. Ayrton, F.R.S., at the Central Institution of the City and Guilds of London Institute, takes place this afternoon at 5 o'clock, and will be repeated on Wednesday next at the same hour. The fee for the course, which is £1 11s. 6d., is reduced in the case of teachers, or of several students coming from one firm, to 15s. each.

The Gulf Stream.—The following letter reached us too late for insertion in its proper place:—"There are many of your readers who doubtless take an interest in the nature of the Gulf Stream and in its peculiarities, and are pleased, like myself, at your diverging on this occasion from your usual track. The Gulf Stream and its source will always prove of an argumentative character; but two points in connection with it appear to have been omitted from the interesting paper you have published, and which have a bearing on the question. The first is that the temperature of the Gulf Stream proper—I mean that between Havanna and Key West—is enormously higher than the equatorial current of Wyville Thomson, even at a depth below 100 fathoms, showing that if Thomson's theory be true the water must undergo a very great heating process somewhere in the Gulf of Mexico, as the highest temperature appears to be arrived at when the current is at its smallest surface extent. The second point is the omission of the strong westerly or *under* current which exists below the Gulf Stream and for a considerable depth, the exact depth not being known. A westerly current is mentioned running along the Cuban shore as a 'counter-current,' but the true counter-current is under the Gulf Stream itself, and is of such considerable force and velocity, that in paying out the first Havanna cable this current was powerful enough to carry the suspended cable *against* and through the Gulf Stream current. The surface and under-currents here appear, therefore, very similar to those in the Straits of Gibraltar. The under or westerly current therefore, will have an important bearing on the question of the Gulf Stream, as it tends not only to compensate for all loss due to evaporation, but also the replacement of the body of water carried out in the Gulf Stream itself, which no one seems to properly account for.—MANCHESTER."

Mill Lighting.—Mr. Wilson Hartnell has just completed the fitting up of Messrs. Croysdale and Son's flour mill at Knottingley. The plant comprises one compound self-regulating dynamo, and some 63 16-candle power Edison-Swan incandescent lamps, distributed throughout the mill, warehouse, offices, stables, yard, &c. The dynamo is driven from the line shaft on the bottom floor, power being supplied by a large water wheel which drives the whole mill. The pendant wires which are exposed have been specially made incombustible.

Retort Manganese Steel.—We beg to call the attention of engineers who have been using so-called mild steel to the new material now being supplied by Messrs. Pfeil & Co. under the above designation. Users of so-called mild steels must have experienced the absence of uniformity in the character of these materials, various bars contained in the same parcel differing in their capacity to either weld, case harden, or forge. Messrs. Pfeil & Co. claim that instead of the ordinary mere mechanical mixture of manganese, &c., with iron, producing from the same blow bars of varying quality, they have a chemical compound, the quality of which can be accurately predetermined, and which is absolutely uniform. From its extreme toughness and reliability it can safely and with advantage replace any of the best makes of iron. It will turn up perfectly clean, case harden to any depth, and with the greatest ease, and it is claimed to make the very best bolt, nut or stud which it is possible to produce. We shall hope in a future number of the REVIEW to give our personal experiences with this material.

Biographical.—A correspondent sends us the following extract from an article headed, "Date of the End of the World," which appeared in a recent issue of the *York Herald*, and suggests that perhaps the printer's boy has been playing the "scientific journalist" on this occasion:—"Sir William Thomson, who owed his knighthood to the share he had in the saving of the Atlantic cable, is one of the most distinguished physicians of our time. Popularly he is best known for his ingenious theory of the origin of life in this planet, which he set forth in his inaugural address as President of the British Association in 1871. The vital germ from which all else was evolved might, he suggested, have been brought to this world on an aërolite produced by the break up of another world that had happened on a collision somewhere in space. He is an LL.D. of Dublin, Cambridge, and Edinburgh, and D.C.L. of Oxford, an F.R.S. of London and Edinburgh, and Professor of Natural Philosophy in the University of Glasgow. Although most famous for his discoveries and inventions in electrical science, he has been president of the Geological Society of Glasgow. He is now 63 years of age, having been born in Belfast in 1824."

Personal.—Mr. W. M. Foxcroft intimates that he has purchased the business of F. Lucas of St. John Street Road, chronometer and surgical case maker, and intends carrying it on as a branch establishment at No. 9, Smith Street, Northampton Square.

Libelling a Gas Manager.—Mr. Ellis Lever, whose name is doubtless well-known to most of our readers, is now undergoing trial at the Manchester Assizes for publishing an alleged libel concerning the manager of the Salford Gas Works, whom he accused of accepting bribes from contractors, and other misconduct.

Secondary Generator Litigation.—The lawsuit between the proprietors of the French patents of Gaulard and Gibbs, and Zipernowsky, Déri and Blathy, after having been decided the first time at Tours in favour of the first-named inventors, has just been carried to the Court of Appeal in Orleans. This Court, we are informed, has ordered Messrs. Zipernowsky, Déri and Blathy to deposit at the Caisse des Consignations, within a period of 15 days from the date of the judgment, the sum of 30,000 francs, independently of payment made at Tours, and to pay the expenses which will be taken upon the first deposit of the sum of 30,000 francs. Moreover, the Compagnie Internationale d'Eclairage Electrique, proprietors of the Gaulard and Gibbs patents, is authorised by the tribunal to demand from Messrs. Zipernowsky, Déri and Blathy any sum which may seem necessary during the course of the proceedings which will follow.

Elieson's Secondary Battery.—We hope shortly to publish some tests made with this system of storage battery, but in the meantime we can more than endorse all that we said last week about the wonderful virtue of the plates to withstand rough usage. We have had sent to us an unformed plate, and positive and negative plates from a battery which has been in use for about a year. These can be bent about in any manner and dropped from a height to the floor without suffering the least damage. If the electrical constants of the battery are at all commensurable with its mechanical merits it is the ideal of an accumulator for electric locomotion.

The Union Battery.—We understand that Professor George Forbes reports this battery as capable of giving over 10 ampère-hours per pound of *plate*, although the Union Company does not lay claim to this high capacity.

The Judicial Warping of Patents.—Prof. Silvanus P. Thompson, writing to the *Pall Mall Gazette* of Wednesday, remarks that at least one judge (referring to the judgment in the incandescent Appeal case) has the courage to place his veto upon the stretching of patent specifications beyond their just claims.

Mechanics in the Telegraph Department.—We are familiar with the complaints—just complaints, mainly—of the telegraph operators that the same recognition is not extended to them by Government which their more fortunate brethren of the Post Office obtain, but we were unaware that the mechanics employed by the Telegraph Department were also dissatisfied upon the same grounds. That they are seems evident from the tone of an article entitled "Skilled Mechanics and the Post Office," published in the *Newcastle Daily Leader* of last Saturday, wherein the importance of the technical work performed by the mechanics is pointed out, and the inclusion of this deserving class in the "establishment," with the consequent opening of channels of promotion and the extension of privileges enjoyed by employés in other departments, is advocated. The claims of the mechanics seem reasonable and we shall be pleased to see them succeed.

The Jablochkoff Company.—We have been informed that Messrs. Manville and Madgin, of the firm of Woodhouse and Rawson, are joining the *personnel* of the Jablochkoff Electric Light Company.

Conduit Explosion.—An explosion occurred recently in one of the Western Union conduits at Chicago.

Festivities.—The following has been sent us as "news," and we insert it as a choice specimen of picturesque paragraphing:—"Capital and labour, the twin brethren of these kingdoms—unfortunately too often dowered with mutual scorn and hate—were never more united in equable and fragrant fellowship than on last evening, when a company of nearly 40 *employés* and friends sat down to their annual dinner, given by Mr. B. Copson Garratt, Finsbury Square, London. The assembly was honoured by the genial presence of Mrs. Garratt and several of the family, who left nothing undone to promote enjoyment and instruction. The gathering was also made the occasion for an address on the newest advances in magnetic and electrical science, together with uncommonly interesting experiments and phenomena educed by these forces. The 'co-workers' of Mr. Garratt (to use his own expression) could not but feel that they are in the service of one of knightly character, and so deep was this feeling that the old couplet was ever recurrent to the mind—

> 'Twixt kings and tyrants there's this difference known,
> Kings seek their subjects' good, tyrants their own.'

It is a curious coincidence that at the same time Sir William Thomson (perhaps the most distinguished savant of electrical science) was lecturing at the Royal Institution on 'The Birth and the Death of the Sun,' Mr. Garratt had an intelligent auditory enchained by his thoughtful disquisition on 'The modern applications of Light and Heat.' If such re-unions of master and servant were more general, peace and goodwill and brotherhood would infuse their balmy odours amongst the cheerless toil and consuming teen of the world around us."

Electrical Invention in Tasmania.—Letters patent have been granted in Tasmania to Franz Wunderlich, 52, Bourke Street, East Melbourne, for improvements in the electro-chemical process of an apparatus for extracting the various elements from the regulus of smelting ores.

The Farmer Patents.—The Farmer Electric Manufacturing Company, of Portland, Me., has been incorporated with a capital stock of $1,000,000. The president is no other than the veteran Prof. Moses G. Farmer.

A Paradox.—The Third Avenue Road in New York is to be provided with a cable system. The company states that "with some reluctance it abandoned all idea of electricity on account of its expense in the present stage of manufacture and control," and then with a light heart votes to put in a system that will cost it from 25 to 50 per cent. more than the costliest electrical system known. It is difficult, says the *Electrical World*, to understand such procedure, but it is partly explainable by the fact that cable interests are already strong in the road, and by the other extraordinary fact that because the 10 H.P. electric motors will develop, when required, up to 25 H.P., it was declared necessary by the road's present advisers to provide each with steam power on the larger basis of calculation.

Proposed Electric Road for Boston.—One of the leading projectors of the new West End railway to be put down in Boston said recently:—"We proposed originally to use the cable as a motive power, but electricity has *such undeniable superiority* that we have now fully determined to adopt it." The West End Road may very possibly be run by storage batteries, which would have a favourable opportunity on the line.

A Strange Accident.—A fire, starting, it is supposed, in the extensive system of belting, occurred at the station of the Rhode Island Electric Lighting Company, at Providence, R.I., at 4 a.m., on January 15th. Considerable damage was done in the station and building, and about 80 city lights were thrown temporarily out of service. The engineer was suffocated on the spot, and the fireman was fatally burned.

Obituary.—The death is announced of M. Blavier, one of the most distinguished French electricians, chief inspector of the French telegraph lines, director at the School of Telegraphy, and vice-president of the International Society of Electricians. M. Blavier was one of the promoters of the memorable Paris Congress, in 1881, where the absolute system of measurement for electrical and magnetic magnitudes was adopted. His books on telegraphy and on the absolute system of measurement are justly considered standard contributions to science. His experimental researches have also been fruitful of important results, and one of the last series of experiments undertaken was in connection with earth currents, and was carried out with the assistance of Prof. Mascart.

Our readers will hear with regret of the death which occurred on Tuesday morning, at San Remo, of Colonel Sir J. U. Bateman Champain, K.C.M.G., of the Royal Engineers (Bengal), Director-in-Chief of the Indo-European Government Telegraph Department. Colonel Champain's first commission dated from June 11th, 1853. He served in the Mutiny campaign throughout the Delhi siege and preliminary operations, from the actions on the Hindun River and at Badlikeserai to the storming, and was wounded during the siege. In 1862, when the late Lieutenant-Colonel Patrick Stewart, C.B., R.E., was sent to Persia to pave the way for the construction of the Indo-European telegraph, Lieutenant Champain was specially selected to accompany him, and the next year he returned to Persia to carry out the Persian portion of the line. On the death of Colonel Stewart at Constantinople in the beginning of 1865, Champain was associated with Major-General Sir Frederick Goldsmid in the chief direction of the whole system between England and India, and on Sir F. Goldsmid's retirement, in 1869, Champain became sole director-in-chief. Some account of what he and his brother engineers did in Persia during the years of their employment there will be found in Sir F. Goldsmid's work "Telegraph and Travel;" and though their services are little known otherwise, we may say that nowhere has the corps been more ably represented or done better work. Ever since 1869 the direction of this most important system of lines has been in Colonel Champain's hands. All the duties were performed in a way that won the entire confidence of the Government. One of these duties, which recurred pretty frequently during his 18 years' tenure, was the representation of the Indian Government at telegraphic conferences on the Continent, and the tact and judgment with which he represented his Government carried great weight with his foreign colleagues, with whom he was personally very popular from his gay and courteous disposition. His early loss will be widely regretted.

The death is announced of M. Mercadier, Professor of Physics to the Polytechnic School of Paris.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

United River Plate Telephone Company, Limited.—This company has adopted an agreement dated 25th ult., and filed on the 28th ult., between the River Plate Telephone and Electric Light Company, Limited (in liquidation), of the first part; the United Telephone Company of the River Plate, Limited (in liquidation), of the second part, and this company of the third part; the Consolidated Telephone Construction and Maintenance Company, Limited, of the fourth part; F. W. Jones, of 131, Wool Exchange, of the fifth part; Thomas Lloyd, of 34, Walbrook, and C. L. Wingfield Fitzgerald, of 4, Hercules Passage, E.C., liquidators of the River Plate Company, of the sixth part; F. W. Jones and John Kingsbury, of 79, Coleman Street, liquidators of the United Company, of the seventh part. This document specifies that the cash to be paid to the United Company for new telephones, wires, appliances, plant, and material, referred to in agreement dated 22nd November, is not to exceed in amount the sum of £7,000, so that such sum, together with the £3,000 mentioned therein, shall not exceed in all £10,000. The sum of £40,000, payable under the principal agreement, as part of the purchase money to be paid to the River Plate Company, is to be satisfied by the allotment to the liquidators of that company of 8,000 fully-paid shares in the new company.

Continental Etéve Engine Company, Limited.—The annual return of this company, made up to the 9th November, 1886, was filed on the 17th of that month. The nominal capital is £450,000 in £1 shares. The number of shares taken up is 405,115. 400,000 shares are considered as fully paid up, and 10s. per share has been called upon the remaining 5,115 shares. The calls paid amount to £2,647 10s. The amount of the shares for which share warrants are outstanding is £5,500, comprising 500 of £5 and 300 of £10. Registered office, 58, Coleman Street.

Buller, Jobson and Company, Limited (Telegraph Engineers, &c).—The first return of this company, made up to the 3rd January, was filed on the 27th ult. The nominal capital is £108,100, divided into 4,505 A and 900 B shares of £20 each. The whole of the shares are taken up, and the full amount has been called thereon. The calls paid amount to £160. 4,497 A and 900 B shares are considered as fully paid. Registered office, 33, Queen Street.

CITY NOTES, REPORTS, MEETINGS, &c.

Cuba Submarine Telegraph Company, Limited.

THE thirty-first ordinary general meeting of the shareholders in this company took place on Wednesday at the offices, 61, Old Broad Street, under the presidency of Mr. Joaquin de Mancha.

Mr. James Scott, the secretary, having read the notice convening the meeting,

The Chairman, in proposing the adoption of the report and accounts, said he hoped the shareholders would agree with him that the report was very satisfactory. The business of the company went on gradually and prosperously. The number of messages had increased in the half-year by 1,590, but he was sorry to say that the money result was not equally favourable, the improvement being only £1,439. As, however, he had said before, people used codes, by means of which they condensed the number of words used, and therefore the company did not get the full advantage. They had had to repair one or two slight defects in the cables. The shore ends had been repaired, and the report now was that the whole were working quite satisfactorily.

Mr. Alexander F. Low seconded the resolution.

The Chairman, in answer to questions, said the directors had heard of the proposed new Atlantic cable, but although it had been said that the shares in that concern had been allotted, they did not believe that it was going on. Even if the very large capital that was required was raised, it would take some eight or 10 years before it affected their company. He quite agreed with the importance of increasing the reserve fund to £100,000. When that time arrived the directors might call the shareholders together to discuss with them as to returning a portion of the ordinary share capital or making some arrangement in regard to the preference capital.

The motion was adopted, and the dividends recommended (10 per cent. on the preference shares, and 8 per cent. on the ordinary) were declared. A vote of thanks to the chairman and directors closed the meeting.

Anglo-American Telegraph Company, Limited.

THE report of the directors, to be presented to the shareholders this (Friday) afternoon, states that the total receipts from July 1st to December 31st, 1886, including a balance of £2,423 19s. 2d. brought forward from the last account amount to £89,808 17s. The traffic receipts show a decrease as compared with the corresponding period of last year of £54,683, consequent upon competition and a reduced tariff.

The total expenses of the half-year, including repair of cables, &c., as shown by the revenue account, amount to £54,461 13s. 10d.

The balance of revenue, after deducting working expenses, amounts to £35,347 3s. 2d., which the directors, under the powers conferred upon them by the Articles of Association, have placed to the credit of the renewal fund, bringing that fund up to a total of £966,906 3s. 6d.

The company's repairing ss. *Minia* has been engaged during the past half-year in the repair of the Prince Edward Island, Duxbury, Brest and Valentia 1873 and 1874 cables; also of the Direct United States Cable Company's short section between Torbay and Rye-Beach.

The company's system of cables and land wires is in good order, with the exception of the Brest-St. Pierre and St. Pierre-Duxbury cables, the former of which was again broken in deep water at a distance of 600 miles from St. Pierre on November 9th, and the latter in shallow water at a distance of 226 miles from Duxbury on January 9th. The rupture of the Brest-St. Pierre cable is believed to be in a depth of about 2,750 fathoms, and it is feared that its repair will be a long and costly operation. The *Minia* is on her way to the locality of the break, and has been ordered to take a series of soundings in the immediate neighbourhood, which will be done as soon as the weather permits. It is not proposed, however, to commence operations for the repair of the cable before June next.

The Commercial Cable Company (Mackay-Bennett cables) has succeeded during the past half-year in obtaining control of the direction of the Paris and New York Telegraph Company, one of the parties to the joint purse agreements. At a special general meeting of that company, held in Paris on October 6th last, the majority of the old board of directors were replaced by new men, the object of the change being to break up the alliance with the English and Western Union Companies.

On December 31st last, the new managing director of the French Company gave formal notice to the other companies that the joint purse agreements would thenceforth be at an end so far as regarded his company, the reason assigned being a letter from M. Granet, the French Minister of Posts and Telegraphs, that the French company were with respect to those agreements not acting in accordance with the terms of their concession. This decision of the French minister is directly opposed to that of his predecessor, M. Cochery, to whom the principal agreement was duly submitted in 1881 before it came into operation.

The directors are advised that the action of the French company is illegal, and that in the event of continued refusal to carry out their engagements, heavy damages can be obtained by the other parties to the agreements.

The tariff at 6d. per word has been in operation during the whole of the past half-year, and has resulted in a still further increase of traffic carried by the associated companies. For the eight months since May 5th, it has amounted to 129 per cent. more than for the corresponding period in 1885. During the last three months of the year, however, the increase was 122, 145, and 151 per cent. respectively, as compared with the same months last year, which shows that the large increase at first noticed is progressing satisfactorily, and encourages the directors to hope that if the improvement of trade between Europe and America should continue, the permanent establishment of low rates may become an accomplished fact.

A new cable company has been launched during the past half-year. The prospectus of the International Cable Company, for cables between Europe and North America, *viâ* the Azores, was issued in the month of November, and notwithstanding the depressed condition of all the existing cable companies to America, and the fact that there are already ten cables across the Atlantic, some of the shares of the new company were allotted, although the stocks of the old companies could have been bought at from 60 to 75 per cent. discount.

The foregoing facts point to the necessity of continued efforts on the part of the associated cable companies to maintain low rates. It is probable that had high rates been in force when the prospectus of the new company was issued the whole of the capital offered would have been subscribed.

National Telephone Company, Limited.

At a meeting of the directors on Wednesday it was resolved to declare an interim dividend for the six months ending December 31st last at the rate of 6 per cent. per annum on the first and second preference shares, and at the rate of 3½ per cent. (as against 3 per cent. for the corresponding period last year) on the ordinary shares, and that the balance of £727 13s. 2d. should be carried forward. The unaccrued revenue carried forward to the credit of next account amounts to £38,722 4s. 4d., as against £34,058 18s. 10d. last year.

The Submarine Telegraph Company, Limited.—The accounts for the half-year ended December 31st, show a balance, subject to audit, which enables the directors, after adding 15 per cent. of the gross receipts to the reserve fund, to recommend a dividend at the rate of 15½ per cent. per annum.

TRAFFIC RECEIPTS.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending January 28th were £3,256 after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited.

The West India and Panama Telegraph Company, Limited. The estimated receipts for the half-month ended the 31st January are £2,78[illegible], as compared with £2,859 in the corresponding period of 1886. The October receipts, estimated at £3,907, realized £3,916.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1885.

15268. "Improvements in appliances for regulating the electromotive force or current of electric currents, and the speed of motors." C. J. BOSANQUET, W. CAMERON and W. A. TOMLINSON. Dated December 12. 8d. Claims:—1. The system of levers forming a differential gear upon which are contacts for distributing the current in electric circuits. Part of the system receiving a motion from a solenoid, or other electrical device, which completes a circuit, the second motion tending to break the circuit being received from the gear under control of said solenoid. 2. The combination, as in claim 1, with the contact maker resting on a third contact point when in mean position, to shunt the current through resistances instead of breaking the circuit.

1886.

40. "A construction of mechanical telephone." W. MCPHERSON. Dated January 1. 8d. Claim:—For equilibrating strain on the diaphragm of a mechanical telephone, in combination with the diaphragm and the connecting wire, a ring connected by wires that are adjustable in tension to a second ring supported against the diaphragm, substantially as described.

335. "Improvements in voltaic batteries." D. G. FITZGERALD. Dated January 8. 8d. Claims:—1. In the manufacture of peroxide of lead elements for voltaic batteries, the production of a hydrated compound of oxide of lead and glycerine by making the lead oxide into a paste with a fluid composed of glycerine in admixture either with water or with a saline solution, or with a dilute acid, as and for the purpose specified. 2. The manufacture of a compound structure to be converted into a peroxide of lead element, consisting of a superficially peroxidised central core or support of either the oxide of lead and glycerine compounds specified, coated with an external layer or layers of one of the more porous and readily convertible oxide of lead compositions referred to, substantially as specified. 3. In the manufacture of a compound structure for a peroxide of lead element, as herein specified, the combination with a superficially peroxidised central core composed of either of the lead oxide and glycerine compositions specified, and with an external layer or layers composed of a different oxide of lead compound as specified, of a contact strip or strips of platinum in contact both with the peroxidised surface of the core and with the external layer as specified. 4. A peroxide of lead element having that part of its surface where contact is to be made prepared or coated with plumbago or blacklead, as specified.

584. "Improvements in telephone apparatus." S. A. EDWARDS. Dated January 14. 8d. Claim:—The application to telephone apparatus of arrangements to enable the apparatus to be portable without being detached from its wires, such arrangements consisting in means for giving out and drawing in the length of connecting wires.

639. "Improvements in the method of and in apparatus for erecting overhead telegraphic, telephonic, and similar wires." J. POOLE and K. MACIVER. Dated January 15. 11d. Claims:—1. The method of conveying a cord or wire across a span, which consists essentially in carrying one end of the cord or wire by means of a "creeper" or carrier apparatus capable of traversing or of being caused to traverse the span by travelling upon an existing wire. 2. In a creeper or apparatus for travelling upon an existing telegraph or similar wire, two clutches capable of being moved along the wire in one direction only, substantially as and for the purpose hereinbefore described and as illustrated on the drawings. 3. In a "creeper" or apparatus for travelling upon a telegraph or similar wire, two or more grooved pulleys, one of which may be intermittently or continuously rotated, substantially as and for the purpose described and as illustrated on the accompanying drawings.

668. "Improvements in electric telegraph printing receiving instruments." F. H. W. HIGGINS. Dated January 15. 1s. 1d. Claims:—1. The escapement wheel and anchor with stop surfaces meeting approximately radially to the centre of the escapement wheel. Also with propelling surfaces and with intermediate surfaces on the escapement anchor approximately concentric with the escapement wheel, substantially as described. 2. The apparatus actuating the escapement consisting of the divided armature polarised through its pivot pieces by a permanent magnet and situate between the pole pieces of a compound electro-magnet, substantially as described. 3. The type wheels formed as described from polygon wheels with flat faces by engraving or cutting the required letter or character on each flat surface, substantially as described. 4. The mechanism for shifting the type wheels along their axis to bring one or other of them into use, consisting of a part carried on the printing lever and engaging with the said wheels, which part when at the proper time the printing lever is raised is moved by being so brought against pins or projections rotating with the type wheels, substantially as described. 5. The mechanism for advancing the paper consisting of a retaining pawl and lip or flange and a driving pawl and surface, the said driving pawl being mounted on a lever actuated by the printing lever, substantially as described. 6. The combination with an electric telegraph printing receiving instrument of gear substantially as described in respect of the figs., by which whilst winding the maintaining power is continued in operation, and the working of the instrument not interfered with.

11991. "Improvements in telephones and telephonic systems." A. J. BOULT. (Communicated from abroad by W. Marshall, of New York.) Dated September 21. 8d. Claims:—1. In a telephonic system with speaking condensers, an induction coil at each station, said induction coil having two secondary wires and a primary wire, the opposite ends of each secondary wire being connected to the opposite poles of the speaking condenser for the purpose, substantially as described. 2. In a telephonic system, the within described induction coil having two secondary wires and a primary wire, one of the secondary wires being connected with a speaking condenser, and the other with the line wire and a polarising battery, substantially as and for the purpose specified. 3. In a telephonic system the within described induction coil having two secondary wires and a primary wire, the primary wire being connected with the microphone and the battery, substantially as and for the purpose specified. 4. A speaking condenser, the opposite plates of which are loose except at one end, and formed as intersected electrometers, the electrodes having independent connections, substantially as described and shown.

13312. "Improvements in printing telegraphs." J. H. LINVILLE. Dated October 19. 2s. 4d. Relates to a printing telegraph system and apparatus of the class in which rotating type wheels controlled by escapements are used in connection with impression devices operated by electro-magnetic devices; and the object of the invention being to print messages, stock reports, and other financial or commercial matters with increased rapidity and accuracy in page form on sheets of paper or upon continuous rolls of paper, in lines, in paragraphs, or columns, that is to say, telegraphically printing messages, stock reports, &c., similar in form and arrangement, on the transmitting instrument simultaneously with their transmission to a receiving instrument, or printing on instruments, which may be combined or which may be so organised as to be operated interchangeably as a transmitter or receiver, or which may be so arranged as to be operated as an independent transmitter or receiver; the change from a combined transmitting instrument to a receiving instrument being readily and effectively accomplished without auxiliary gearing or motive power through the manipulation of a switch, as described. The claims are 91 (!) in number.

13340. "Improvements in tubes or conduits for laying underground electric conductors, and in insulating coverings for electric conductors." H. E. NEWTON. (Communicated from abroad by E. D. McCracken, of America.) Dated October 19. 8d. According to this invention, tubes or tube sections are employed, which are composed of strips of vegetable paper, wound spirally one on the other, and secured by India-rubber or other suitable cement, the tube sections being waterproof, and serving effectually to insulate the conductors or conductor sections which are in them from earth currents of electricity, and serving also to protect the conductor sections from moisture. Such a tube or conduit constitutes one feature of this invention. The claims are 5 in number.

13341. "Improvements in machines for covering and insulating electric wires." H. E. NEWTON. (Communicated from abroad by E. D. McCracken, of America.) Dated October 19. 8d. An important object of this invention is to provide a machine whereby wire for electrical purposes may have applied to it an insulating covering, consisting of a spirally wound and lapping strip or strips of paper, the paper being applied with adhesive substance, and forming of itself, the insulating covering for the wire. The claims are 11 in number.

PROCEEDINGS OF SOCIETIES.

The Society of Telegraph-Engineers and Electricians.

THE second ordinary general meeting for the year of this society was held on Thursday, January 27th, Sir CHARLES BRIGHT, president, in the chair. The minutes of the last ordinary general meeting having been read and confirmed, and the list of new and proposed new members announced, a paper on "Telephonic Investigations" was read by Professor SILVANUS P. THOMPSON, D.Sc., member.

If we except the researches of Graham Bell and Tainter upon the photophone, which have as yet not been made of any commercial value, it is just to say that no great scientific progress was made between 1879 and 1885; for the much-applauded methods of Van Rysselberghe for the perfection of long-distance telephony are a mere commercial extension of the researches of Black and Roseburgh in 1878-9.

Yet it cannot be said that the lull in telephonic invention and discovery has arisen from the absence of need for further improvements. The need exists for better, cheaper, more reliable instruments—for instruments less subject to interference from currents which stray into the system by induction and by leakage—for instruments which will work over longer distances. In our own metropolis Mr. Langdon Davies has produced a series of inventions which might well claim the attention of this society, comprising as they do that novel kind of transformer the phonopore, the phonoporic telegraph, and the open-circuit telephone. Already we hear of duplex and even multiplex telephony—of special methods for long distance telephoning, and of other kindred advances.

The various telephonic systems may be classified as follows:—

I. Transmitter < line wire / return wire > receiver.

II. Receiver < line wire / return wire > receiver.

This is Graham Bell's system; either receiver being used as transmitter.

III. Transmitter – transformer < line / return > receiver.

This is the one in common use.

IV. Transmitter – transformer < line / return > retransformer receiver.

It may be convenient here to give a systematic table of all the principal classes and genera of transmitters. The three classes relate to the way in which the sonorous vibrations are made to affect the electric system, by varying (1) the resistance; (2) the electromotive force; (3) the capacity of the circuit or of a part of it.

CLASSIFICATION OF TRANSMITTERS.

I. *Varying Resistance.*

1. Loose contact	
with diaphragm ...	Reis, Berliner, Blake, &c.
without diaphragm...	Hughes.
2. Liquid resistance	
in external circuit ...	Yeates, Gray, Graham Bell, Edison.
in battery	Graham Bell.
liquid jet	Graham Bell, Ch. Bell, and Tainter.
3. Short-circuiting ...	Edison.
4. Compressible semi-conductor	Edison.
5. Photo-electric... ...	Graham Bell and Tainter.
6. Tribo-electric	Edison, Bidwell.
7. Crookes' layer	

II. *Varying Electromotive Force.*

1. Magneto-electric methods:—	
Moving conductor in magnetic field / Varying magnetic field around conductor	Graham Bell, &c.
Varying co-efficient of mutual induction	Spottiswoode
Varying co-efficient of self-induction ...	G. J. Stoney
2. Electro-capillary	A. Breguet.
3. Thermo-electric	

III. *Varying Capacity.*

1. Vibrating condenser plates ... ...

My own researches in this part of the subject have been somewhat desultory. So far back as the end of 1878 I observed that if a thermopile is placed so as to receive the radiations from a singing flame, a sensitive receiver of appropriate low resistance placed in the circuit will repeat the vibrations. I devised at that date a special transmitter, in which the voice vibrations were led into a Kœnig's manometric capsule, so that the gas flame connected therewith, being thrown into vibrations in correspondence with the voice, might affect a thermo-electric transmitting apparatus.

Later, I worked at the problem of securing a more direct correspondence between the voice waves and the electric impulses of the transmitter than was the case with many of the transmitters which were used in great variety in the years 1878-82. The circumstances which in such instruments as the Blake transmitter and in the Wollaston transmitter (commonly known as the Gower-Bell) occur to cause this lack of correspondence are various. All diaphragms have tones of their own—not always well defined, but still obviously present. A diaphragm having a low fundamental tone gives the voice a "boommy" sound, while a diaphragm of too shrill a tone gives the voice a "tinny" sound. Moreover, all springs have tones of their own. Further, instruments such as the Blake transmitter, the operation of which is to open or close the contact to a greater or less degree in proportion to the vibrations, do not always do so. Some sudden, powerful sound taken up by the diaphragm gives the light contact mechanism behind it such a sudden forcible thrust that the electrodes are forced wholly, instead of partially asunder, and the resistance, instead of varying in any exact inverse proportion to the displacement, increases suddenly to infinity. And the result is not merely a lack of correspondence between the sound wave and the electric impulse; for, as instruments are generally arranged, another phenomenon takes place at this stage. The sudden complete parting of the electrodes is followed by a spark due to the self-induction of the circuit; and the spark, being a sudden electric discharge of excessively short duration, produces a harsh and loud noise in the receiver. Many persons call this noise the noise of make and break. It is nothing of the sort. Making of the circuit and breaking of the circuit can be accomplished without any such disturbance, provided the extra current sparks are suppressed. Another point is less easily stated. All the transmitters in which carbon contacts are used are defective in their transmission of

certain sounds, particularly the sibilants and shrill whistling sounds. At one time I was of the opinion that this circumstance was not the fault of the transmitter at all, but arose from the receiver, which, in consequence of its self-induction, "throttled" (to use Lord Rayleigh's term) the more rapid fluctuations of the electric current. I was undeceived in this view by finding substances other than carbon which, when used for contact points in the transmitter, enabled me, while still using the existing receivers, to transmit the sibilants with extraordinary crispness. Lastly, none of the transmitters at the date in question, save the Hunnings and the Gower-Bell, were as loud as was desirable. All the others required a very sensitive receiver, with the necessary result that the receiver received too much—was so sensitive as to be subject to the intrusion of all sorts of stray electric impulses, tending to drown its own small voice.

The problem was to find a form of instrument which, while admitting of more powerful currents being used than was possible with any of these forms, would neither spark at the contacts, nor necessarily require the intervention of a diaphragm to collect the sound-waves. I am far from asserting that the presence of the diaphragm—and I use the word in the undistorted sense in which it was used ten years ago—is in all cases a detriment to a transmitter. On the contrary, in many cases it is extremely important to have one, in order to concentrate on a mechanism that otherwise would be inoperative the force derived from the impact of the sound-waves over a considerable area. I make use of this feature of construction in one of my most recent forms of instrument. There are other forms of instrument without any diaphragm, and which are better without any.

The discovery that no diaphragm was necessary was proclaimed by Hughes and by Edison early in 1878. But, when one tried to construct practical microphone transmitters without any diaphragm to collect and concentrate the air-waves, it became apparent that the diaphragm had also served another function, namely, to intercept the moisture of the breath, which otherwise would condense on the electrodes and impede their action. Hence, in omitting the diaphragm in order to secure a more direct correspondence between the voice-waves and the electric impulses, it became necessary to devise means for getting rid of moisture. A short length of speaking-tube furnished all that was wanted. In the spring of 1884 I devised the "Nest" telephone,* so called because in it the working parts, instead of being mounted on springs, reposed in a sort of nest made of cotton wool or slag wool. Some nests had in them contact pieces shaped like eggs; others mere coke granules, the air waves impinging through a speaking tube from above.

In conjunction with Mr. Philip Jolin I next devised the Valve† form.

The loudness of the Valve telephone is limited by the fact that it is not expedient to work with more than three contact points, the limit being a natural geometrical one familiar to every constructor. When, therefore, still louder instruments are desired, either several separate valves must be combined, or some other form of instrument must be employed admitting of a larger number of contacts being introduced. A form of instrument which answers extremely well, and is both simple and handy, consists of a *grid* or row of microphonic pencils mounted in an open frame and provided with a convenient rubber-covered handle through which the conducting wires pass. There are several ways of using the "Grid" telephone—it may be mounted above the call-bell with the handle vertical, or it may be held in the hand and simply talked to, the voice-waves striking direct upon the microphonic pencils. But there is a third way in which it may be used, namely, that suggested so far back as 1878 by our esteemed Past-President Mr. Preece, in this very room, when he showed that Hughes's microphone required no air-waves to operate it, but might be placed against the forehead, face, or breast. About the same time Prof. McKendrick found that the mechanical vibrations of the throat could work a microphone direct.

The transmitter that I have constructed for long distance working has many microphones—108 in all, arranged in 54 parallels, the pencils being two in series. They can also be arranged all in parallel if desired. This mode of using the transmitter is, by the way, quite successful. But if the number were further increased, the amplitude of motion imparted by the diaphragm would be insufficient. Hence I have sought other ways of obtaining mechanically the requisite energy, leaving the voice the work of controlling the motions. A method of doing this, which promises good results, was suggested by Edison's "motographic" receiver. Against a slowly rotating friction roller presses an extension of the rod that supports the central bars of the layers of microphones, and agitates them with a drag and slip motion. The voice is made to affect the pressure upon the slipping surfaces, and so control the periods of drag and slip. In experimenting in this direction several points of interest in the theory of microphonic contact presented themselves, and are worthy of attention.

First of these points was the effect of heat on microphonic contacts. It is a matter of common knowledge that microphonic contacts work more satisfactorily when warm than when cold. Hunnings's transmitters of granulated coke work best when heated by the current. Ochorowicz has produced a special telephone transmitter—the details of which are still kept from publication—in which a preliminary heating is brought about by using a powerful current. I have tried various arrangements of microphones in which heat was led from a small gas jet by copper rods or tubes to heat the working contacts, but have not arrived at any final form. At one time I was under the impression that the heat served simply or chiefly to increase the energy of the vibrations imparted by the voice. But further experiment showed that this was at least a crude view, for I found that if one of the two pieces in contact were heated, the microphonic joint became more sensitive to sound when the other was kept cool. In fact the actual transfer of heat across the loose contact of the circuit seems to facilitate its action as a telephonic transmitter. In studying this point I came upon another fact, namely, that the layer of vapour which exists between a drop of acidulated water in the so-called spheroidal state and the hot metal plate beneath it will also act as a microphonic transmitter, though from its high resistance and instability it is a rather unmanageable sort of transmitter.

There is an obvious incompleteness about both of the rough-and-ready theories which are commonly accepted, viz., that microphonic action is due (1) to the variation of resistance of the material under pressure, and (2) to the variation of the number of points of contact between the surfaces. The first view is known to be wrong; but is not the second, as thus stated, terribly imperfect? Little as we know yet about the exact kind of motion which constitutes heat in a body, we know at least this, that the heat in a solid body is a motion, vibratory, oscillatory, or rotatory of its particles. We know that the surface particles of every substance that is not at the absolute zero of temperature are animated incessantly with minute motions which are of an irregular kind not timed together, otherwise the body would emit rays of one frequency only, not all executed in the same direction at the same instant, otherwise the emitted rays would be polarised rays. We know that their average amplitudes increase, and that their average frequencies also increase, with increase of temperature; but this brings us almost, if not quite, to the boundary of present knowledge. We know, further, that the most highly polished surfaces we can obtain may be, molecularly speaking, quite rough. A ridged surface whose corrugations are less than a half-millionth of an inch in breadth is perfectly flat to all optical tests, but such ridges might contain from 500 to 2,000 rows of separate molecules. A metal surface one-millionth of an inch square may have from 4,000 to 16,000 molecules on its top surface. Think of two surfaces such as we have to deal with in telephonic transmitters, say one of platinum and one of carbon. Both rough, both heated by the passage of the electric current, that is to say, each having its molecules in violent agitation, and ready to discharge electricity from the surface of higher to that of lower potential. Let these two be resting lightly in what we commonly call "contact:" what a jostling of molecules, what innumerable batterings, what millions of minute electric discharges; air particles, nay, even solid dust particles torn from the two surfaces, flying to and fro between them, forming a veritable Crookes's layer. Then think what is the meaning of putting more pressure on to such a "contact." The thousands of molecular makes and breaks that were going on will be multiplied; the paths of the flying molecules shortened; more current will flow; heat agitations become still more energetic. Take off the pressure, the two surfaces fling one another apart, or bombard one another apart; discharge takes place more slowly; the apparent conductivity of the layer is reduced. Move the surfaces still further apart, the atomic clash and atomic bombardment is still further enfeebled. Separate them by a visible distance—like the spheroidal drop separated visibly from the hot plate beneath it—still there are the flying molecules at work between them. Will any one undertake to say that at sensible distances, such as one-thousandth of an inch, or even one-hundredth of an inch apart, no discharge takes place at all across the gap? Think of this, and then meditate on the shallowness of the dictum that when two clean platinum contacts are used in a transmitter, the current must be either wholly on or wholly off, either "made" or "broken," with a sharp transition *per saltum* between the state when the two surfaces are in perfect contact and the state when the two surfaces are not in contact at all. Think of the utter fatuity of the dictum that a transmitter cannot transmit unless the contact surfaces are "semi-conductors." The more one thinks of the matter from the point of view of the molecular vibrations, the more plain is it that every transmitter that works by varying the resistance of the circuit—every one of Class I. in the table of transmitters—works by varying the number of molecular contacts, and that the most perfect transmitter will be the one that does this in the most effective correspondence with the displacements in the air caused by the speaker's voice, and will give the effect of undulation when the air particles merely undulate, and will give the effect of intermission when there is intermission between the motions.

The foregoing considerations will perhaps make more intelligible the action of heat in assisting microphonic action. It is my opinion that what heat can do can also be done by auxiliary vibrations of such periods as shall not interfere with the tones of the voice. I have had an apparatus lately constructed to test this matter.

The mere fact that the vibrations corresponding to a certain sound stop for a short time does not necessarily produce on our ears any discontinuity in the sound. To assert that discontinuous electric impules cannot set up and maintain a continuous vibration in the armature of a telephone receiver would be as absurd as to assert that discontinuous impulses cannot set up and maintain the continuous rotation of a flywheel or the continuous oscillation

* ELECTRICAL REVIEW, May 9th, 1885.
† ELECTRICAL REVIEW, April 25th, 1885.

of a swing. But it is hardly worth while to prove by argument what has been abundantly demonstrated in fact.

As regards materials for transmitters, amongst natural minerals I have tried the following:—Native arsenic, mispickel, ilmenite, allemontite, specular iron ore (black crystals), magnetite, micaceous iron, cloanthite, pentlandite, clausthalite, redruthite, chalcopyrites, smaltine, and pyrolusite. Some of these were better than others; but the best, micaceous iron, was difficult to obtain in workable pieces. Artificial preparations of copper treated with tellurium, and copper treated with selenium or with mixtures of selenium and sulphur, gave results of surprising character. A hard and brittle sort of bronze formed in this way takes a brilliant polish like steel, and yields, when used against a platinum point, an articulation which for crispness far surpasses anything to be obtained from hard carbon. At one time this bronze was used for the valve pieces of the valve transmitter, but although the articulation when the ball valve was newly polished left nothing to be desired, it was found to acquire from the moisture of the air a film, probably of selenic acid, at the contacts, which gave rise to curious, shrill whistling sounds. Mr. G. L. Anders has made excellent transmitters of osmium and of palladium. Nickel also answers fairly well. There is a great difference between different materials with respect to the range of amplitude of vibrations suitable for them. For the metals in general the range of amplitude of motion must be very small; they require almost rigid connections. With hard carbon and with the copper-selenium composition the range is much greater. The copper-selenium composition requires a greater initial pressure at the contacts than hard carbon does. So also does chalcopyrites, which has recently been suggested by Mr. P. Rabbidge. In our present state of knowledge of the properties of those bodies which possess quasi-metallic conductivity, it is difficult to frame any explanation of these facts, or draw a useful deduction from them.

The desirability of getting rid of sparks at the electrodes has been referred to. A shunt made of a thin resistance wire (as in Johnson's transmitter), or a liquid resistance, does not satisfactorily accomplish this end, though it mitigates the evil. I have found that the best method is to use a differentially-wound transformer. It may be remarked in passing that this differential method of working is applicable to other transmitters; in particular with sensitively-adjusted transmitters, to which one must not speak too loud, and which are affected by vibration of buildings, the articulation is immensely improved by its use. Even the Blake works excellently amongst the machinery of a factory when provided with one of the differential transformers. The "Valve" telephones are all provided with them. You may shout as loud as you please to these instruments without producing any unpleasant rattling sound. A transformer very similar to that used in the Blake telephone, but with slightly more primary wire, has been found superior to the larger transformers used by the General Post Office in their Gower-Bell telephones. In transformers for telephonic purposes, it is desirable to have such an arrangement as shall give maximum mutual induction with minimum self-induction. As induction coils are usually constructed, it would appear that when the size is increased the mutual induction does not increase proportionally. At any rate, two small ordinary induction coils, having their primaries united in parallel and their secondaries in series, give a better result than the same of wires made up in one single induction coil of similar form. Possibly Mr. Langdon-Davies's phonopore may eventually prove the best transformer for telephonic work.

Upon the table I have several instruments based on the principle of magnetic expansion. They all require stronger currents than the ordinary receivers. Messrs. Alabaster and Gatehouse have worked in this direction also with some success. Next I exhibit a modification of Bell's membrane electro-magnetic receiver, in which the form given to the electro-magnet is the one found to be the best for the attraction of the small disc armature, about the size of the thumb-nail. The coil is surrounded by a circular pole-piece, cut away at one point to hinder eddy currents; this outer pole-piece being of opposite polarity to the central pole-piece.* The pull of such an electro-magnet upon its armature is powerful, and varies greatly with the thickness of the gap between the iron disc and the poles. This modified form of the membraneous receiver is an exceedingly satisfactory instrument. Its magnetism requires to be excited by a current while in use; but when used as I have been employing it, along with the "Valve" transmitter, it proves to be less sensitive to induction than most other instruments; and is, indeed, now in use on lines where, with other instruments, conversation was impossible, owing to the deluge of stray noises.

I have found that two iron wires stretched close together across a sounding board, and traversed by the current, will answer as a receiver; but their natural note interferes with the tones of the voice. A receiver can also be made in which the working parts are two parallel iron cores which repel each other when similarly magnetised.

But my attention has been more directed of late to the object of bringing to bear on the small scale the same general principles which have been found to hold good on the larger scale in the construction of dynamo machines and motors.

The main point of difference is that, whereas in the dynamo-electric machine, whether used as a generator or as motor, the armature rotates, in the dynamo-telephone, whether used as transmitter or receiver, the armature merely vibrates, being pivoted elastically.

In conclusion, I would reiterate my conviction that the success of long-range telephony depends upon the possibility of devising instruments which, on the one hand, can be used with higher battery power to transmit stronger currents, and which, on the other hand, will be adapted to receive these currents by means of apparatus which, though not necessarily more sensitive to small currents than the present receivers, will have a higher electrical and mechanical efficiency. And I am convinced that the path of progress lies very near the road already travelled by those who have perfected the existing machinery for the electric transmission of power.

* ELECTRICAL REVIEW, May 9th, 1885.

DISCUSSION.

In the discussion which followed the reading of Prof. Thompson's paper,

Mr. W. H. PREECE said that there was a very great deal in the paper from which he utterly and totally dissented. Taking the last conclusion to commence with, he most emphatically denied that long-distance telephony was a question of instruments, it was a question of the line wire entirely. He would remind the Society of the paper read by Van Rysselberghe, in which the experiments on the 1,000 mile line between Chicago and New York had been recounted. He himself had made very numerous experiments on all kinds of wires and with all kinds of instruments and the conclusion come to was, that to get long-distance speaking you must have a line free from electro-magnetic and electrostatic induction. He had within the last few days carried out some experiments on a new copper wire line recently erected between Hanwell and Nevin (on the Welsh coast), a distance of 270 miles. The conductor resistance of the wire was about 5¾ ohms per mile. The speaking on this line was as perfect as could be desired, being even more satisfactory than that over a line a mile or two only in length; the sibilant and whistling sounds came out perfectly. The results proved that long-distance speaking could be carried on with the most ordinary kind of apparatus. He tried speaking with the first Bell instrument which he had brought over from America and with perfect success. If other wires had been used speech would have been out of the question. The next point to which he would object was the historical question; he thought it most unjust and ungenerous to bracket the names of Varley and Wray with those of Edison and Bell. In 1876 no one had heard of the possibility of transmitting speech. When he went over to America he did so with the intention of showing up the fallacy of what had been rumoured, but Prof. Bell soon convinced him of the possibility of what had been stated. Van Rysselberghe had, he thought, been roughly handled by being bracketted with Black and Roseburgh. Van Rysselberghe had not worked with the idea of obtaining long-distance telephony, but of working telephones and telegraphs simultaneously on the same circuit. He thought Prof. Thompson was rather too fond of introducing new terms, such as calling an induction coil a transformer, a change which was quite unnecessary. He might mention that Captain Cardew had found that it was possible to dispense with transformers altogether. The objection which Prof. Thompson had raised to the use of the word semi-conductor was, he thought, rather curious, inasmuch as he himself used the word "quasi-metallic." In the case of telephones, as in all other cases, inventors raised imaginary difficulties and then set to work to find means for getting over the same. It was somewhat inconsistent, he thought, to deny the use of carbon and then to adopt a modified form of the Hughes microphone. He thought that Prof. Thompson while defining the questions to be solved, had avoided stating what was the real object aimed at, viz., the evasion of the United Telephone Company's patents. He thought that there was much unfairness in the matter of patent rights, as when a person brought out a good thing he should be fully protected from attempts to get the better of it; he did not like the many attempts that were made to undermine work done. As the time was short, he would continue his remarks at the next meeting.

The meeting then adjourned.

CORRESPONDENCE.

Fire and Life Risks in Electric Lighting.

I have read Dr. George H. Benjamin's communication to the Electric Club which is published in the ELECTRICAL REVIEW of December 17th, and think that credit is due to him for boldly venturing where others "fear to tread." The subject is one that should not be allowed to remain in the present uncertain state; only a few months ago one of your correspondents appealed against the severity of the inspection of the Fire Insurance Companies, and other letters made one infer that very divergent opinions are held. If we recall to mind the fact that the Fire Risk Rules were originally settled by a Committee of the Society of Telegraph Engineers in 1882, and that the Committee have not met since that year, although electric lighting is now carried out on systems which were then unthought of,

the rules must be somewhat out of date. Good service has certainly been accomplished by the Phœnix Office, who have from time to time issued new editions of their regulations; but even these, if Dr. Benjamin's are correct, require extension; and new rules should be issued bearing the stamp of a selected committee who might invite the opinions of all interested. A committee is something like a public company in that it has "no body to be kicked," and can report without the "bitter and personal discussion" you mention. It is well known that fires have taken place which are due to the electric light, and it would be interesting if the professional adviser of the Phœnix Office would publish his notes on some of the installations where he has been called in to survey. The public often only know the advantages of the electric light and are unaware of the dangers of an unprotected installation; as a proof, the case of the Bombay Yacht Club may be quoted, two fires having recently occurred which were clearly due to the overheating of the conductors. On inspection I was not surprised, as there are no cut-outs and the native drivers thought the lights improved when the "wires warmed up."

Killingworth Hedges.

Bombay, *January* 11*th*, 1887.

Sir Charles Bright's Presidential Address.

My attention has been drawn to an anonymous letter in your last number, signed by "Manchester."

I never write anonymous letters myself, and, as a rule, disregard them, considering that any person without the courage to sign his name is unworthy of notice.

As, however, in the present case, gross mis-statements are made, I think it desirable to expose them.

1st. Mr. Varley was never, to my knowledge, engineer of the Electric Telegraph Company. I have before me the reports of that company which I received as a shareholder, in which he only is referred to as the electrician and not as engineer.

As to the claim put forward that Mr. F. C. Webb should have been noticed in my presidential address reviewing the main incidents of telegraphy during the past fifty years, and especially as regards the Atlantic cables; I can only say he was not on board any ship during my laying of the first Atlantic cable in 1858 (as he was then in the service of Mr. Newall elsewhere).

I am not aware that he had been employed by anybody in the laying of any subsequent Atlantic cable.

Regarding the first telegraph line completed to India, which I laid as engineer in charge for the Government in 1864, Mr. Webb was one of my many assistants, but the notion of "Manchester" that the success was "mainly attributable to him" is simply ludicrous.

All of Messrs. Bright & Clark's staff employed by them on that work received their due meed of commendation in a paper read by me at the Institute of Civil Engineers ("The Telegraph to India, &c.," by Sir Charles Tilston Bright, M.P., M.Inst.C.E., *Proceedings of Inst. C.E.*, vol. xxv., Session 1865-66), in which I specially mentioned the names of my various assistants, viz., Mr. J. C. Laws, Messrs. Bright and Clark's chief of the staff; Mr. F. Lambert, Mr. F. C. Webb, Ass.Inst.C.E.; Mr. T. Alexander, Ass.Inst.C.E.; Mr. T. B. Moseley, Ass.Inst.C.E.; Mr. T. Brasher, Mr. J. E. Woods, Mr. E. Donovan, Mr. E. D. Walker, and Mr. P. Crookes.

In my brief historical address there was no space, necessarily, for enumerating the many names of the assistants whom I have had in my various works, as my hearers were referred in every case to the publications on the subject.

Nevertheless, I should regret if any of my former *employés* are possibly ruffled by their names not coming forward once more in print.

Respecting the experiments on undeground wires, they were first made on those of the Magnetic Company, which were laid long before those of the Electric Company to which your anonymous correspondent alludes.

Charles T. Bright.

January 31*st*, 1887.

Reversible Batteries.

Perhaps it is scarcely possible, where there are such wide differences in views and opinions—as well as in interests and perhaps in prejudices—as those which exist between Mr. Sellon and writers who know something of the more recent improvements in reversible batteries, that a discussion should take place without some things being said that may appear offensive to the disputants respectively. What, for instance, is more likely to give offence than the persistence with which Mr. Sellon ascribes to the directors of the Union Company the almost incredible blunder of proposing to transport large quantities of spongy lead in a dry state—simply because they state that "the weighty box and fluid" need not be transported? His assumption that they are so ignorant and so ill-advised in such a vital matter must be the more irritating from the fact that particular attention has been given to the means of transporting the spongy lead elements with perfect safety in a moist condition. Some of Mr. Sellon's recent observations in your columns have not been very pleasing to myself personally, as will be readily understood by Dynamicables and others who may know what my views are as to the best available means for carrying out small installations of electric lighting—at least until such time when a very large capital can be invested in underground copper conductors. I am sure, however, that, in attacking *inter alia* a system that I have suggested as being feasible, but which may appear to him ridiculous, Mr. Sellon had no intent to wound my susceptibilities; but if, in attacking one of Mr. Sellon's patents which seems to me very open to objection I have appeared to attack himself, I beg to disclaim any such intention, and to express my regret for anything he may consider offensive or unfair.

I feel strongly, and perhaps a little bitterly, on the subject of attempts to monopolise in anticipation, the field in which workers must labour in order to effect improvement. They are, *meâ sententiâ*, indefensible even from the commercial point of view. What with scientific reputation-mongers on the one hand, and unduly grasping patentees on the other, the single-minded and unobtrusive worker in science is constantly impeded, snuffed out, and relegated to the background. Fortunately, the patent law is not always adverse to him; its intent and its effect may sometimes coincide in protecting him. In the first place, it prevents any *kudos* that may attach to his humble and patient work from being ascribed to some "authority," surrounded by a little adulating clique of his own, with whom science may be in great measure an art. Then, as Mr. Fletcher Moulton said the other day:—"The function of the court (the legal tribunal which he was then addressing) is to be the arbitrator of whether the patentee had performed his duty to the public. First, did he make the invention? Second, did he tell the public how to use that invention? Third, had he told the public the information necessary to make it?" The spirit of the law is expressed in the advice given to inventors by Baron Pollock in the case of Crossley *v.* Potter. "The safest course for patentees to adopt in framing their specifications is, instead of claiming everything, to confine themselves to one good thing; and a jury will always take care that if he be a real inventor, no man under colour of improvement, shall be allowed to interfere with that which is the offspring of his genius." No less pertinent is the observation of Baron Alderson, in the case of Morgan *v.* Seaward:—"If the invention can only be carried into effect by persons setting themselves a problem to solve, then they who solve the problem become the inventors of the method of solving it." Can Mr. Sellon really think that his case is improved by the publication of the specification he mentions?

Mr. Sellon strikes out somewhat wildly; and he can have no idea of the effect produced, by a comparison of some of his statements, in the case of those who have some knowledge of "lithanode" and of the positive plates produced from the same material. Thus he refers to the simple use of the words "not celluloid,"

in brackets, as my "hyper-criticism, not to say disingenuousness, in dealing with the word cellulose." Admitting, *par politesse*, that the latter is the "base" of celluloid (although this statement would more correctly apply to the highly nitrogenised body, *pyroxylin*), it must be admitted also that the two substances are as dissimilar physically as they are chemically. Neither this fact nor the non-existent hyper-criticism can be "nullified" by reference to a patent (which I do not remember ever to have seen) taken out by a gentleman whom Mr. Sellon designates as my "partner." He makes the statement that he "succeeded in obtaining results certainly better than can be obtained from the sample he has seen of the Union Company's plate." This would be as difficult to contradict as it would be to establish, were it not for Mr. Sellon's further statement that "his experience of such plates as those now put forward is that they gradually, sometimes rapidly, deteriorate, unless kept charged to an extent which may bring about disintegration," and that the interior, "except where in close contact with the platinum," generally becomes "sulphated up." But it is very easy to prove, and it will be proved, that this experience does not in any way apply to plates such as those put forward by the Union Company, and that, therefore, Mr. Sellon has never obtained results within measurable distance of those which can at any time be exhibited with the plates in question.

Not only so; but Mr. Sellon is evidently in absolute ignorance as to the nature of these latter results, and cannot realise even the possibility of obtaining anything approaching them. He prefaces his "very rough figures" with the words:—"Granting the capacity *claimed* of 5 ampères (ampère hours) per lb. of battery plate." The italics would seem here to signify that the claim is one that can be allowed only for the sake of argument. But, according to the *Times* report, the claim of *over* 5 ampère hours is per lb. of *battery*—a very different thing to "per lb. of battery plate," and a result no doubt quite beyond Mr. Sellon's conception. Nevertheless, it is considerably more than a year since I wrote that "The minimum effective charging capacity of the positive element has been roughly estimated in practice to be 2 ampère hours per ounce avoirdupois of oxide of lead used in the construction of the element; whereas the minimum effective charging capacity of the negative element is estimated to be 1 ampère hour per ounce of litharge used." The effective charging capacity of the negative element is actually from 17 to 25 ampère hours per lb. of oxide of lead. At the present time I should be sorry to "pass" any plates which, taking positives and negatives in the aggregate, together with their mountings, had an effective charging capacity of less than 8 ampère hours, or 15·2 watt hours per lb. Nor can this be regarded as an unreasonable *minimum* value, since an effective capacity of 10·5 ampère hours can actually be shown. And let me further state that I should condemn as worthless any plates that could be made to exhibit signs of disintegration by overcharge, or which, after six months' continuous use, became to any extent "sulphated up," or even showed the smallest patch of "white sulphate."

Mr. Sellon's calculations do not apply to any scheme for the distribution of electrically-stored energy that I should consider rational or practicable. I should never dream, for instance, of sending plates to a distance of ten miles; nor of replacing them every day, Sundays included. It would be very easy, on the lines followed by Mr. Sellon, to show that my milkman (who will send horse and cart, man and can to deposit even a ha'p'orth of milk at the area door) must be financially in desperate case. Nevertheless I believe that the fellow is making his fortune much faster than I am making mine. One thing, I think, is certain; that those who sell electrical energy must, in years to come, reckon, like him, on small profits and quick returns. Ten shillings per lamp per evening may sound "very fine and large;" but something like 2d. per hundred candle-hours may prove to be much more to the purpose, practically and commercially, from the point of view both of the producer and of the consumer.

Desmond G. FitzGerald.

Secondary Batteries.

A few lines will, I hope, be sufficient in answer to Mr. Sellon's letter in your last issue, and since that gentleman appears to have taken my last "effusion" in rather bad part, I will endeavour this time to be strictly serious.

Were I to take Mr. Sellon's statements seriatim I should occupy too much of your valuable space, and I will therefore confine myself to the question of the position which Mr. Sellon takes up in relation to secondary batteries in general, and the "Union" battery in particular.

Mr. Sellon commenced by attacking the "Union" battery, which he had not seen, and with the details of which he was wholly unacquainted. Now here we are at once introduced to a curious case of mental perversion. The effect on Mr. Sellon's mind of the mention of a secondary battery outside of the Faure, Sellon, Volckmar, &c., &c., patents is analogous to that which a red rag has on the mind of a bull; but in his case there is something more than an external cause at work; there is also an internal factor, self-evolved. Mr. Sellon has raised up in his own mind a great blank barrier, a dense impenetrable medium, which not merely obscures his own vision, but which he fondly imagines has the same effect upon others. He has surrounded himself with a charmed circle of patents, outside of which it is true lies nature in all her infinity; but then he tells us that some five or six years ago he explored this infinitude, he ransacked creation for a secondary battery, and having returned with the spoils, he is absolutely certain that in no corner of the universe is such a thing as a new idea to be found, nor can the ground which he has endeavoured to till, but ultimately abandoned, be made to bring forth any fruit.

Here, then, we have the key to Mr. Sellon's position, the explanation of the blindness of his attack. He does not even see what it is he is attacking. It looms before him in that dense medium of his imagination, the form and shape of a secondary battery, issuing from out of that region which he has already explored, and with a fearful malediction he rushes to the death struggle.

Now for his own words. He says, of solid peroxide plates:—"The study of such a form of plate requires at least a year of persistent and careful investigation under varying conditions before a fair report upon it *can be possible*." And yet, without even seeing the "Union" plates, he is able to report that they are worthless! Why? Simply and solely because he himself failed to manufacture a similar plate which would stand the test of time. He does not take the trouble to ascertain how long the "Union" plates have been in use. He takes it for granted that they are new and crude. To make himself acquainted with the position and claims of his rivals is quite beneath him, not worth the trouble indeed.

One more instance of this I may give. Mr. Sellon figures out a so-called estimate for the system of supplying customers with battery plates, and by an ingenious method of extension he produces a very alarming total. He professes to base this estimate on the capacity "*claimed*" of 5 ampères per lb. of *battery plate*, whereas the Union Company *claim* 5 ampère hours per lb. of battery *total*. Is this wilful perversion of published details, or is it simply the result of the *medium* to which I have alluded?

Acid.

[Our correspondent has already figured in this controversy, therefore we insert his second letter, but at the same time we beg to draw his attention to the remarks in our leading columns on the subject of anonymous correspondence.—EDS. ELEC. REV.]